THE EFFECTS OF
HOSPITAL COMPETITION, MERGERS, AND
HOSPITAL FACTORS ON
QUALITY OF CARE AND HOSPITAL COSTS

By

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ABSTRACT

Effects of hospital competition, mergers and hospital factors on quality of care and hospital costs

Background: In early 2000, Taiwan encountered major health reforms including the merging of several regional hospitals. Hospitals in Taiwan have been under unprecedented pressure to seek ways to manage their costs and improve the quality of care. As such, the study aims to provide evidence on what factors are associated with quality of care and hospital costs. Also, as research has provided inconsistent results on the effects of hospital competition on quality of care, this study applies meta-analysis to examine the effects of hospital competition on quality. The study aims to build a foundation for further analyses on the factors that may influence quality of care and hospital costs.

Methods: The study uses various databases to identify, analyze, and summarize literature on hospital competition associated with quality of care. A meta-analysis is performed to investigate the effect of hospital competition on quality of care based on the studies selected. Also, the study assesses the association between hospital levels, location, ownership, merged/non-merged and quality in terms of process measures by applying the generalized linear mixed model (GLMM) and using hospital level data between 2011 and 2014 from the Ministry of Health and Welfare (MOHW). Moreover, the study employs the General Linear Mixed Model (GLMM) to examine the relationship between hospital costs and hospital factors in terms of year, merged/non-merged, ownership, locations, hospital level, the number of acute beds, and occupancy rate of acute beds.

Results: The meta-analysis of the effect of hospital competition depicts that hospital competition insignificantly deteriorates quality of care. The results on the association between hospital factors and quality of care show that a hospital's quality may be affected differently by the hospital's type, ownership, merger, and location. Furthermore, the study examines the association between hospital costs and merged/non-merged hospitals, the number of competitors, hospital ownership, hospital levels, location, the number of acute beds, and year. The results indicate that the number of acute beds, the occupancy rate of acute beds, and year are significantly associated with hospital costs.

Conclusions: The study identifies the potential factors that may contribute to the quality of care and hospital costs. Although there are other factors that may also influence quality of care and hospital costs, this study provides a foundation for further investigation and analyses on these associations. In view of the growing healthcare expenditures and the aging population in Taiwan, it is crucial for policy makers to consider implementing more effective policies to reduce medical waste and ensure good health outcomes concurrently.

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Acute: The percentage of inpatients admitted to acute beds for more than 30 days

AMI: The emergency department visit rate for acute myocardial infarction patients who return to the hospital within 3 days after discharge

Antibio3: The percentage of patients receiving antibiotics treatment for over 3 days after debridement

BHNI: Bureau of National Health Insurance

ED: Emergency Department

ER1: The percentage of patients being treated in the same ED returning to the ED the same day after being treated

ER3: The rate of ED visits for patients who return to the hospital within 3 days of discharge

ER48: The percentage of patients staying in the ED for more than 48 hours before being admitted

HHI: Herfindahl-Hirschman Index

MOHW: Ministry of Health and Welfare

NHI: National Health Insurance

NHS: National Health Services

OECD: Organization for Economic Cooperation and Development

Revisit: The rate for outpatients revisiting the same hospital the same day after being treated for the same disease

CHAPTER 1: INTRODUCTION

Background

Since the implementation of global budget programs in 2002, hospitals in Taiwan have been under unprecedented pressure to seek ways to manage their costs and improve the quality of care. Competition among providers has thus become fierce since all providers want to maximize their share in the common budget by increasing their service volumes (Cheng, 2015). In an attempt to improve the competitiveness, decrease costs, and increase market share of the regional hospitals, the government merged ten local regional hospitals into a single large entity. Consequently, the merged hospital became the largest healthcare organization in Northern Taiwan, serving the medical needs of a population of approximately 2.6 million people in Taipei. However, during the process of the merger, there were some difficulties and problems mainly due to the resistance to these changes from the employees (Udn News, 2005). As a result, the merged entity suffered from a shortage of care providers that led to a deterioration of the quality of care (Lin, 2006), and some of the merged hospitals were later closed. Each merged hospital functions as a branch of the organization as a whole.

According to the literature on hospital mergers (Dranove and Lindrooth, 2003; Dranove and Shanley, 1995; Guerin-Calvert and Maki, 2014; Romano and Balan, 2010), they can lead to a reduction of costs due to the elimination of duplication in services and equipment, and thus can improve quality of care. Moreover, hospital mergers are often associated with anticompetitive practices since they can lessen competition (U.S. Department of Justice, 2015). In fact, some hospital mergers have created regional monopolies or multi-hospital conglomerates. These lead to post-merger price increases due to reduced competition in the market and enhanced market power of the combined hospital (Capps et al., 2004; Makary, 2015). Competition has been used to enhance productivity in health care in countries such as Australia, Belgium, Germany, Netherlands, Norway, and the U.K., (Bloom et al., 2010). However, healthcare programs such as Taiwan's National Health Insurance (NHI), the U.K.'s National Health service (NHS), and U.S.' Medicare regulate the prices, so hospitals compete with each other based on quality (Chen and Cheng, 2010; Bevan and Skellern, 2011). Although various studies apply multiple outcome measures to examine the effect of hospital mergers on hospital costs or quality of care, based on the author's research, the number of studies that use identical outcome measures is scarce. However, various studies on hospital competition associated with quality of care utilize identical outcome measures such as death rates. Because there is no existing systematic review and meta-analysis on hospital competition associated with quality of care, this study aims to perform a pilot systematic review and meta-analysis to ascertain the extent that hospital competition is associated with quality of care. Furthermore, while there are many factors that affect hospital costs and the quality of care, research on the association of hospitals characteristics (such as ownership, levels, and locations) and hospital costs or quality of care is sparse in Taiwan.

The thesis examines three main aspects: 1) A systematic review of the effect of hospital competition on quality of care. 2) The effects of hospital merger, ownership, levels, location on hospital operating costs. 3) The effects of hospital merger, ownership, levels, location on quality of care. In Chapter 3, the systematic review includes various empirical studies on the effect of hospital competition on quality of care. Chapter 4 examines the effects of hospital ownership, levels, location, and merger on quality of care using seven quality measures. Chapter 5 examines the effects of hospital merger, ownership, the number of acute beds, occupancy rate, location, the number of competitors, and time on hospital costs. Both Chapter 4 and 5 utilize the data of 106 hospitals located in northern, central, and southern Taiwan between 2011 and 2014 in Chapter 4 and 2012 and 2014 in Chapter 5 from MOHW. The results of each study are presented at the end of each chapter.

Research Objectives and Study Aims

Literature reviews are often discussed in the beginning of a research article; however, such literature reviews may not include a comprehensive synthesis of all relevant studies. According to the author's research, there is no systematic review and meta-analysis on hospital competition associated with quality of care. This may be due to the variety of outcome measures that each study uses. The literature review by Bevan and Skellern (2011) and Gaynor (2003, 2006) seems to be the only reviews on hospital competition associated with quality of care. While Bevan and Skellern (2011) only synthesize findings of studies in the U.K., Gaynor (2003, 2006) reviews studies from both the U.S. and U.K. There are various studies on hospital competition associated with quality of care and many of them utilize identical outcome measures such as 30-day AMI mortality rates. Hence Chapter 3 of this study intends to add to the existing research on the effects of hospital competition associated with quality of care by performing the pilot meta-analysis to synthesize, analyze, and summarize the empirical findings of more recent studies (i.e. after the year 2000) on hospital competition associated with quality of care. By doing so, this study aims to provide more recent results on the effect of hospital competition on quality. These results can then be used to develop new perspectives and to identify possible directions for future research.

Chapter 4 aims to contribute to the research on the effects of hospital mergers, ownership, levels, and location on quality of care in Taiwan. The findings of the study provide objective and valuable information that may help policy makers to develop effective strategies that will create better policies to improve efficiency and quality of care for local hospitals. The main goal of this study is also to provide a foundation for further analyses on quality of care with a broader set of quality measures and diagnoses.

Although the NHI has implemented various measures to contain costs in recent years, the long-term sustainability of the NHI is questionable as Taiwan is now facing a growing aging population and decreasing family sizes (Liu and Shen, 2015). As such, finding out the potential factors that may influence hospital costs and derive policy attention to address the issues driving up hospital costs may contribute to the long-term survival of the program. Moreover, while there is abundant research about price effect, cost reduction, and quality of care associated with hospital mergers in the United States, empirical research on the effects of hospital merger, ownership, the number of acute beds, occupancy rate, the number of competitors, location, and time on quality of care in Taiwan is sparse. Thus, this study aims: 1) To identify the factors that may affect hospital costs; 2) To add to the existing limited literature on the association of hospital factors with hospital costs.

Hypotheses/Research questions

Chapter 3 intends to find out the following:

i. What are the findings from the literature on the association of hospital competition and quality of care?

ii. What is the result from meta-analysis?

iii. Is there heterogeneity? What are the sources of heterogeneity?

iv. What new directions for future studies are derived from the study?

In Chapter 4, the study examines whether the quality of care is associated with hospital merger, ownership, levels, and location, using seven quality indicators such as AMI patients' rate of returning to emergency department (ED) of the same hospital due to the same or similar disease within 3 days after discharge, the rate for outpatients revisiting the same hospital the same day after being treated for the same disease, the rate of inpatients staying in acute beds for more than 30 days, the rate of returning to ED of the same hospital within 3 days after discharge, the rate of returning to ED within 1 day after discharge, the percentage of patients receiving antibiotics treatment for more than 3 days after debridement, and the rate of patients staying in ED for more than 48 hours. Chapter 4 intends to answer the following key questions:

1. What are the characteristics of the hospitals that achieve better quality of care?
2. What are the new directions for future research?

In Chapter 5, the study examines whether hospital operating costs are associated with hospital ownership, merger, the number of acute beds, occupancy rate, the number of competitors, location, and time. The main dependent variable is total hospital operating costs. Chapter 5 intends to answer the following key questions:

I. What are the hospital factors that are associated with hospital costs?

2. What are the directions for further work?

The hypotheses and assumptions of Chapter 4 are as follows:

- Hospital merger, ownership, levels, and location are associated with quality of care.
- The number of acute bed size and quality is positively associated.
- The number of competitors and quality is positively associated.

The hypotheses and assumptions of 5 are as follows

- Hospital merger, ownership, the number of acute beds, occupancy rate, the number of competitors, location, and time are associated with quality of care.

- The number of competitors and hospital costs are negatively associated.
- The number of acute beds, occupancy rates and hospital costs are positively associated.

CHAPTER 2: EXPANDED DISCUSSION OF METHODS

Chapter 2 illustrates the conceptual framework that constructs the foundation of this research on the effects of hospital factors associated with costs and quality of care. The definitions of the variables used are also described in this chapter.

Conceptual Framework

Theoretically, hospital mergers can achieve efficiency, cost reduction, and improved quality of care as a result of improved access to care and technology, reduced administrative and overhead costs, elimination of redundant services, and realignment of services of larger scale operations (Ibid). In the U.S., studies on hospital mergers have become prevalent since recommendations for merging hospitals began in the 1960's (Angrisani and Goldman, 1997). Various studies have investigated the effects of hospital mergers associated with costs, prices, and quality of care. Empirical evidence on mergers associated with quality and costs provides mixed results as depicted in the literature review section in Chapter 4 and 5. According to Connor et al. (1997), only certain levels of hospital mergers lead to cost reduction, and the merger groups which have been studied have varied (Connor et al., 1997). Moreover, differences in the methodologies and approaches of the studies as well as the locations and market conditions of the mergers may result in different merger effects (Guerin-Calvert and Maki, 2014). However, it is evident that when hospitals' prices are fixed such as in Taiwan, then hospitals compete based on quality of care (Chen and Cheng, 2010; Chang et al., 2004). Although there can be a positive correlation between the quality of care and the size of a hospital (Dranove, 1998), mergers can result in increased administrative complexity which results in less efficient hospitals and poorer patient outcomes (Town, 2011). However, as shown in the literature review section, there are no definite conclusions with regards to the evidence of hospital mergers on the quality of care. A variety of studies demonstrate that a high volume of health services is associated with better patient outcomes. Since the merged hospitals consolidate their services, they could produce larger volumes of health services with smaller range of health services, resulting in better patient outcomes (Capps, 2005). Quality of care can be improved through the merging of hospitals when one of higher quality of care is merged with one of lower quality of care as the hospital with the higher quality of care is then able to show the other hospital how to improve (Ibid). If the merged entity achieves economies of scale and better management, it should achieve cost savings and better patient outcomes than non-merged hospitals.

While literature depicts that hospital merger is one of the factors that can affect hospital costs and quality of care, research also demonstrates that there are other factors that can influence hospital costs and quality of care. Besides hospital merger, there are other contributing factors that have impact on hospital costs and quality of care such as hospital size, occupancy rate, lengths of stay, aging population, hospital ownership, level, location, technology, and the number of competitors. However, based on the author's research, empirical evidence on the effects of these factors on hospital costs and quality of care in Taiwan is not as abundant as in the U.S. Moreover, structural contingency theory indicates that both organizational and environment factors are main determinants for institutional performance (Jiang et al., 2006; Donaldson, 2001). In fact, research demonstrates that factors such as patient related factors (i.e. type of disease and socio-demographic factors), hospital related factors (i.e. physician motivation, physician competency), and market factors (i.e. healthcare system, resources) can affect hospital costs and quality of care (Hung and Chang, 2008; Mosadeghrad, 2014). Furthermore, empirical findings of various studies indicate that factors such as the number of competitors, hospital ownership, level, location, technology or aging population is significantly associated with hospital costs and quality of care (Eggleston et al., 2008; Chang et al., 2004; Chang, 2011; Hsieh and Cheng, 2011; Hung and Chang, 2008; Lin et al., 2003). However, the results of existing literature on the effects of these factors associated with hospital costs and quality of care are mixed. This may be due to the differences in quality measures, methodology and countries. Due to the availability of data, this study focuses on certain hospital related factors. Figure 2.1 illustrates the conceptual framework.

Data Source

PubMed and Google Search are the main databases used for the systematic review and meta-analysis in Chapter 3. In Chapter 4 and Chapter 5, the main source of data is from the Ministry of Health and Welfare (MOHW).

Description of variables

All variables used in this research are described below:

Number of acute beds

The number of acute beds is an annual average number compiled by MOHW. It is used as a measurement of hospital scale or size (Shepard et al., 2000).

Occupancy rate

It is an annual average rate for the acute beds occupied in each hospital. The rate is provided by each hospital which then reports this rate to MOHW periodically.

Total operating costs

Total operating costs are those that related to the core business of the hospitals (Connor et al., 1997). They include drug costs, medical equipment costs, depreciation, rental fees, research and development fees, medical social service costs, administration and personnel costs, and other medical services expenses. Since 2014, hospitals are required to disclose their financial statements. These financial statements are published in MOHW's website (http://www.nhi.gov.tw) which is open to the public. So far the website contains the financial statements of most hospitals from fiscal year of 2012 until 2014 but it does not have the financial statements of all hospitals in Taiwan.

Number of hospitals

The number of beds reflects the intensity of competition in the market (Wong et al., 2005). It is the annual average number of hospitals in the same marketplace. The marketplace is defined by an area code. Hospitals with the same area code are considered to be located in the same marketplace. The number of hospitals is compiled by MOHW which annually publishes such data in its website.

Merged hospitals

The merged hospitals include Taipei City Hospital, New Taipei City Hospital, and Kaohsiung City Hospital. For Taipei City Hospital, ten regional hospitals were merged into one. For New Taipei City Hospital, two regional hospitals were merged into one. For Kaohsiung City Hospital, three regional hospitals were merged into one. The level of all the merged hospitals is regional hospital based on the accreditation result in Taiwan. In this study, the three merged regional hospitals are horizontal mergers in which the merged hospitals are located in their original geographic markets, operate in separate facilities, and are owned by each city government. It is also a consolidation of a multi-hospital system except that the merged city hospitals report unified financial reports.

Hospital ownership

Ownership is either private owned or public owned in this study. Public owned hospitals are those owned by the government. Private owned hospitals include those that are owned by charitable foundations and local corporates.

Hospital levels

In Taiwan, all hospitals are accredited by the Taiwan Joint Commission on Hospital Accreditation which classifies hospitals into three levels in accordance with their quality of care, number of beds, medical teaching and clinical capabilities (Wu et al., 2013). There are three hospital levels based on accreditation: medical centers, regional hospitals, and district hospitals. The information on hospital level is from MOHW website.

Hospital location

This study includes the three locations in Taiwan: northern, central Taiwan, and southern Taiwan. Northern Taiwan includes Taipei City, New Taipei City, Keelung City, and Yilan City. Central Taiwan includes Taichung City, Chunghwa City, and Nantou City. Southern Taiwan includes Kaohsiung City and Pintung City.

Time

In Chapter 5, time is an independent variable. The time period of data in Chapter 5 is from 2012 to 2014.

Quality indicators monitored by the NHI (NHI, 2016) and obtained from MOHW website (used in Chapter 4 only):

The emergency department visit rate for Acute Myocardial Infarction patients who return to the hospital within 3 days after discharge (Abbreviation: AMI)

If AMI patients revisit the emergency services after discharge from the hospital within 3 days, it may signal that the hospital's care for AMI patients is ineffective as such instances can be avoided with adequate medical care and health education. This rate is the annual average rate.

The rate for outpatients revisiting the same hospital the same day after being treated for the same disease (Revisit)

The reasons that patients returning to the hospital after being treated the same day may be due to patients' seeking second opinion from a different doctor in the same hospital, inadequate medical treatment received in the previous visit, or insufficient medical education. Nevertheless, hospitals that have rates higher than others may reflect poor quality of care. This rate is the annual average rate.

The percentage of inpatients admitted to acute beds for more than 30 days (Acute)

If a hospital has a higher percentage of patients staying in acute beds for more than 30 days than other hospitals, then this signals that that hospital may be inefficient in managing inpatient beds and providing acute care. This rate is the annual average rate.

The percentage of patients staying in the emergency room for more than 48 hours before being admitted (ER48)

The rate shows how efficient a hospital's emergency room is in treating patients with acute illness or serious injuries. If a hospital has a higher rate than other hospitals, then its hospital's care for patients in the emergency room may be less productive than others. This rate is the annual average rate.

The percentage of patients receiving antibiotics treatment for over 3 days after debridement (Antibio)

According to the NHI, the process of debridement requires absolute sterility or sanitation and the use of antibiotics is for prevention (2016). Thus, a treatment period of 3 days is sufficient. However, if a hospital has a percentage higher than the average, the hospital shall investigate the reasons for such a statistic. This rate is the annual average rate.

The rate of emergency department visits for patients who return to the hospital within 3 days of discharge (ER3)

Patients who return to the hospital through the emergency room within 3 days of discharge may be due to various reasons such as unstable conditions and poor medical compliance. However, when a hospital has a higher rate than other hospitals, this may signal that the hospital needs to improve the quality of inpatient care. This rate is the annual average rate.

The percentage of patients being treated in the same emergency room returning to the emergency room the same day after (ER1)

According to the NHI, patients should not be discharged from hospitals if any of the following conditions exists:

1. Life signs are unstable.
2. Complications are not under control.
3. Injuries are seriously infected, including bleeding or swelling that cannon be treated through outpatient services.
4. Patients (except patients receiving kidney dialysis) have difficulty urinating.
5. Treatments through intravenous injections need to be continued and cannot be removed right away.
6. Patients transferring to another hospital due to non-medical reasons.

7. Patients requiring inpatient treatments.

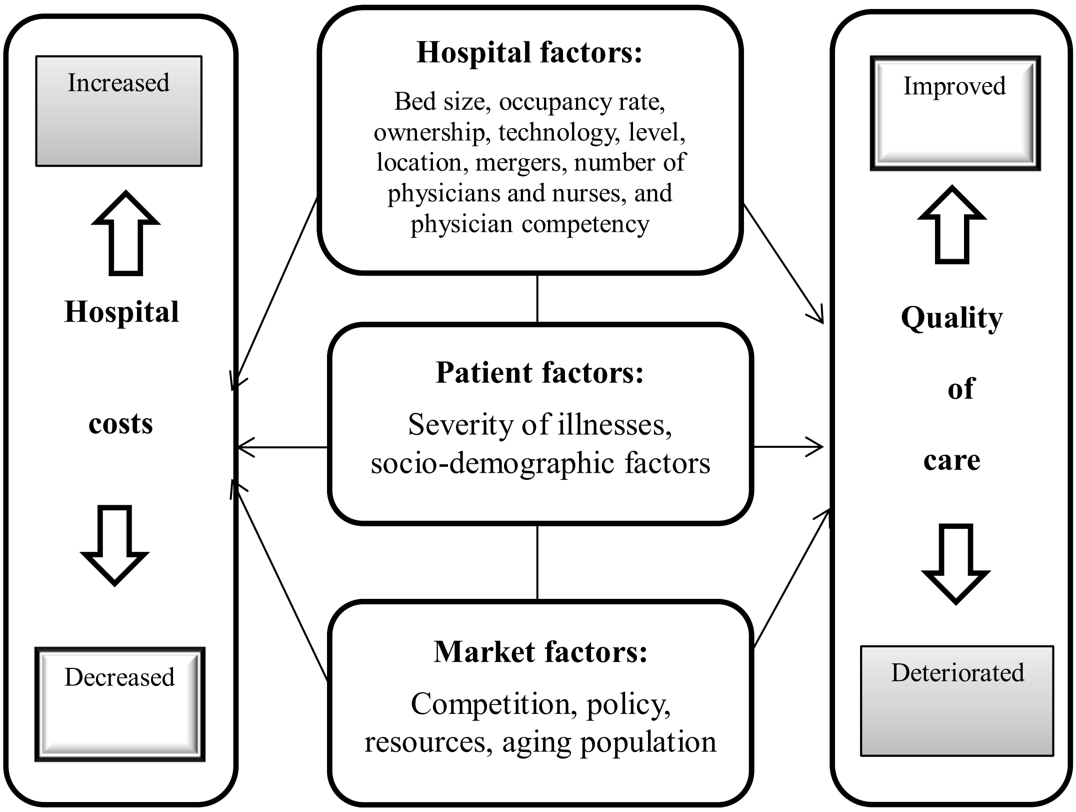
This indicates the adequacy of the care in a hospital’s emergency department. A higher percentage could mean that the emergency department needs to improve its efficiency and quality of care. This rate is the annual average rate. Table 2.1 depicts definitions of variables and sources of data.

Table 2.1 Variable Definitions and Data Source

Variables	**Type**	**Coding**	**Data Source**
Merged	dichotomous	0 (non-merged hospitals) 1 (merged hospitals)	MOHW website
Hospital ownership	dichotomous	0 (private) 1 (public)	
Hospital level	categorical	1 (medical centers) 2 (regional hospitals) 3 (district hospitals)	
Hospital location	categorical	11 (northern Taiwan) 22 (southern Taiwan) 33 (central Taiwan)	
The number of acute beds	continuous	0 and above	MOHW website
The average occupancy rate of acute beds	continuous	0 to 100%	MOHW website
Total hospital operating costs	continuous	0 and above	MOHW website
The emergency department visit rate for Acute Myocardial Infarction (AMI) patients who return to the hospital within 3 days after discharge (AMI)	continuous	0 to 100%	MOHW website
The rate for outpatients revisiting the same hospital the same day after being treated for the same disease (Revisit)	continuous	0 to 100%	MOHW website
The percentage of patients admitted to acute beds for more than 30 days (Acute)	continuous	0 to 100%	MOHW website
The percentage of use of antibiotics for over 3 days after debridement	continuous	0 to 100%	MOHW website

(Antibio3)			
The rate of emergency department visits for patients who return to the hospital within 3 days of discharge (ER3)	continuous	0 to 100%	MOHW website
The percentage of patients staying in the ER for more than 48 hours before being admitted (ER48)	continuous	0 to 100%	MOHW website
The percentage of patients being treated in the emergency room returning to the emergency room the same day after being treated (ER1)	continuous	0 to 100%	MOHW website
Outcomes of Interest			
Pooled effect of hospital competition on quality of care	Linear	Beneficial (coefficient < 0) Harmful (coefficient > 0) Association is significant if $P < 0.05$, insignificant if $P > 0.05$.	
Association of hospital mergers, hospital ownership, hospital levels, hospital location on quality of care	Linear	Beneficial (coefficient < 0) Harmful (coefficient > 0) Association is significant if $P < 0.05$, insignificant if $P > 0.05$.	
Association of hospital mergers, hospital ownership, hospital levels, hospital location, the number of acute beds, and average occupancy rate of acute beds on total operating costs	Linear	Beneficial (coefficient < 0) Harmful (coefficient > 0) Association is significant if $P < 0.05$, insignificant if $P > 0.05$.	

Figure 2.1 Conceptual framework linking hospital factors with hospital costs and quality of care.



CHAPTER 3:

SYSTEMATIC REVIEW AND META-ANALYSIS ON THE EFFECT OF HOSPITAL COMPETITION ON QUALITY OF CARE

Abstract

Background and Purposes: Various empirical studies use a range of data, quality measures and methodologies to examine the association between hospital competition and quality of care. However, the results are still inconclusive which may be due to the differences in methodologies, locations, time periods, patient groups, and quality measures (Chen and Cheng, 2010). Therefore, this study applies meta-analysis to the results of the studies in the Western countries addressing the same research question with an aim to derive a conclusion regarding the effect of hospital competition on quality of care and to build a foundation for further analysis on studies using different quality measures.

Methods: This study is a systematic review and uses meta-analysis to combine results from various studies to obtain an overall outcome. Measure of effect size, I^2 test, meta-regression to find sources of heterogeneity, tests for publication bias, sensitivity analysis and cumulative analysis are performed. The mean effect size is estimated by coefficient and standard error with P values less than 0.05 which is considered statistically significant.

Results: Based on the selection criteria, only 11 studies are included for this meta-analysis. The pooled effect of hospital competition on quality of care is reported by all of the 11 studies that are included in the analysis. The results of the meta-analysis suggest that hospital competition reduces quality of care, but the overall effect is relatively insignificant from a statistical perspective (Point estimate = 0.008, 95% CI = -0.004 ~ 0.020, $P > 0.05$) (Figure 3.1).

Conclusion: Based on the findings from this study, hospital competition slightly increases AMI mortality rates, although such negative impact is statistically insignificant. However, such negative impact can be expected to lessen over time as medical technology, practices, and techniques continue to improve. Indeed, this downward trend is consistent to the findings in prior research (Mutter et al., 2008).

Introduction and Background

Economic theory suggests that competition leads to better quality in price-regulated markets where price is set above marginal cost. Firms would compete based on non-price dimensions such as quality, and would enhance quality to increase market share until profits are equal to zero (Ganor et al., 2010). However, when firms set the prices, the impact of competition on quality depicts mixed results (Gaynor, 2006). Indeed, various countries, such as the UK and Taiwan, adopt a fixed price regime that causes hospitals to compete based on quality. As a result, hospitals in such markets need to improve quality of care to attract patients. Various empirical studies use a range of data, quality measures and methodologies to examine the association between hospital competition and quality of care. However, the results are still inconclusive which may be due to the differences in methodologies, locations, time periods, patient groups, and quality measures (Chen and Cheng, 2010; Mutter et al., 2008). As meta-analysis statistically synthesizes the results from multiple related studies and systematically examines the underlying effect, it provides a logical framework that can reduce bias and improve the precision in estimating these reactions (Borenstein et al., 2009; Fragkos et al., 2014; Pan, 2013; Warrier et al., 2015). Therefore, this study applies meta-analysis to the results of the studies in the Western countries addressing the same research question. Based on the author's research, this study is the first meta-analysis on the association of hospital competition with quality of care. Therefore, this study aims to derive a conclusion regarding the effect of hospital competition on quality of care and to build a foundation for further analysis on studies using different quality measures.

Tests for heterogeneity, meta-regression to investigate sources of heterogeneity, tests for publication bias, sensitivity analysis, and cumulative analysis have been performed. The findings are presented in the results section. This chapter is organized as follows: literature review, methods, selection criteria, evaluation of effect, evaluation of heterogeneity and sources, evaluation of publication bias, sensitivity analysis, and cumulative analysis, results, discussion, and conclusion.

Literature review on impact of hospital competition on quality of care

Mixed Results

Mutter et al. (2008) apply negative binomial regression to examine the effect of hospital competition on inpatient quality of care. They utilize 12 hospital competition measures, 38 quality measures and Medicare inpatient discharge data of 2,595 hospitals in 22 states from the 1997 Healthcare Cost and Utilization Project (HCUP) State Inpatient Databases. Mutter et al. (2008) find that there is no correlation between measures of competition and those of quality. However, while the researchers suggest that hospital competition does not directly impact quality of care, they indicate that hospital competition may impact quality in different areas. Similar to the findings of Romano and Mutter (2004), Mutter et al. (2008) also reveal that hospitals that perform well in some quality dimensions could also perform weakly in others.

Moreover, Mutter et al. (2008) suggest that hospital competition seems to enhance quality of care in the dimensions that are related to physician skill, expertise, and areas that are comprehensible to patients. In contrast, quality is reduced in those associated with hospital infrastructure, nursing mix, and hospital staff where the dimensions of quality are less obvious to patients. Mutter at al. (2008) indicate that because physicians are linked to flows of patients, hospitals in a more competitive market want to attract patients by providing the best physicians. Therefore, they are likely to allocate resources to improve quality in areas such as physician skill and expertise as they are more visible to patients. Furthermore, Mutter et al. (2008) point out that in order to manage costs effectively, hospitals may allocate resources to improve quality in one area at the expense of another where the quality of care is less visible to patients, such as infrastructure and support staff.

Similar to the findings of Mutter et al. (2008), a UK-based study by Proper et al. (2008) finds mixed evidence of the effects of hospital competition on quality of care. Proper et al. (2008) utilize administrative data of 145 acute hospitals in the English NHS from 1991 to 1999 and the DID approach to examine the impact of hospital competition on quality of care. The researchers state that competition varies over time due to policy changes and thus use such changes to analyze the impact of competition in the specified period (Proper et al., 2008). Moreover, Proper et al. (2008) state that because competition does not exist in some areas due to geography, the way they are able to distinguish these hospitals from those located in competitive places is by using the number of hospitals located in each catchment area as a competition measure. Proper et al. (2008) indicate that competition reduces less observed measures such as the 30-day AMI mortality rates, while improving well published measures such as waiting lists for treatment. Proper et al. (2008) illustrate that the 30-day AMI mortality rates are higher while the average waiting times and number of persons on waiting list are lower in competitive areas. Similar to Mutter et al. (2008), Proper et al. (2008) also suggest that hospitals in competitive areas tend to focus on improving measures visible to patients at the expense of the unmeasured activities that are poorly observed by the patients.

In an Australia-based study by Palangkaraya and Yong (2013) mixed effects have also been found. The researchers conclude that competition increases mortality but reduces unplanned readmission, although the negative effect of competition on mortality is weak statistically. Palangkaraya and Yong (2013) examine the effect of hospital competition on quality using logistical models and hospital administrative data of patients with heart diseases from 2000 to 2005 from Victoria State in Australia. They use 30-day mortality rates and 30-day unplanned readmission rates as quality indicators in conjunction with HHI and the number of competing hospitals as the competition measures. Palangkaraya and Yong (2013) indicate that while the adverse effect of competition on mortality is relatively the same for both private and public hospitals, the positive effect of competition on unplanned admission is much higher for public hospitals than that of private ones. Palagkaraya and Yong (2013) explain that this may be because that unplanned admissions being one quality dimension that patients could not easily observe, as illustrated by Mutter et al. (2008).

Furthermore, a Dutch study conducted by Bijlsma et al. (2010) finds mixed evidence of the association of hospital competition and quality of care. However, instead of using only outcome measures to empirically examine the effect of hospital competition on quality, Bijlsma et al. (2010) also apply process measures, as they view that hospitals have more control over processes of care which are less likely to be affected by patients' health conditions. They use hospital data from 2004 to 2008 and 18 quality indicators including both process and outcome indicators to assess the relation between hospital competition and quality. To measure hospital competition, Bijlsma et al. (2010) use mainly three measures: number of competitors in the hospital catchment area, number of competitors adjusted for population, and the distance to the nearest competitor. Bijlsma et al. (2010) find a statistically significant effect of hospital competition on process indicators, but an insignificant effect on outcome measures. Thus, Bijlsma et al. (2010) suggest that competition induces hospitals to improve production efficiency. Moreover, Bijlsma et al. (2010) indicate that competition causes hospitals to improve certain quality indicators that are visible to patients as a signal of quality. Furthermore, Bijlsma et al. (2010) find that quality improves as outcome measures such as decubitus, AMI, and reoperations depict more positive results over time. This suggests that increasing policy focus on quality related issues helps improve the quality of care in hospitals.

Improved quality

Kessler and McClellan (2000) examine the effects of hospital competition on quality of care for non-rural Medicare beneficiaries with AMI using Medicare claims data in 1985, 1988, 1991, and 1994. They use risk-adjusted 1-year AMI mortality rates as a primary outcome measure. Instead of using the conventional HHI, which is based on actual patient flows to measure hospital competitiveness, Kessler and McClellan (2000) measure competition with predicated HHI. This is based on predicted patient choice that is determined by each patient's distance from a hospital in relation to their zip code. Kessler and McClellan (2000) find that AMI patients have higher one-year mortality rates in less competitive areas. Kessler and McClellan (2000) indicate that before 1991, AMI patients in the least competitive areas have higher rates of mortality and lower treatment costs than those of patients in most competitive areas. However, as of 1991, treatment of AMI patients in the least-competitive areas has become significantly higher than that of the patients in competitive areas. Also, the mortality rates for the AMI patients in least competitive area are significantly (1.46 percentage points) higher than those of the AMI patients in competitive areas (Kessler and McClellan, 2000).

Extending the study done by Kessler and McClellan (2000), Kessler and Geppert (2005) investigate the impact of hospital competition on quality of care for all non-rural elderly who suffer AMI, and are enrolled in traditional fee-for-service Medicare between 1985 and 1996. Kessler and Geppert (2005) use the Medicare claims data from the Centers for Medicare and Medicaid Service for patient demographic information, and they use data from the American Hospital Association for hospital characteristics so they are able to define patients as high-risk or low-risk based on their health outcomes and expenses. The researchers estimate competitiveness based on the same HHI model used by Kessler and McClellan (2000) as discussed above. Kessler and Geppert (2005) find that patients in the least competitive markets have higher 1-year mortality rates than the rates of patients in the most competitive markets. Moreover, Kessler and Geppert (2005) indicate that while low-risk patients in competitive markets obtain less intensive treatment than they do in uncompetitive markets, their health outcomes are similar. However, high-risk patients in competitive markets obtain more intense treatment than they do in uncompetitive markets, yet they result in significantly better health outcomes (Kessler and Geppert, 2005). Kessler and Geppert (2005) conclude that competition results in better health outcomes and lower expenditures, and thus improves social welfare. In addition, their results are consistent with the findings of Kessler and McClellan (2000) who conclude that a higher level of bed capacity per patient results in higher mortality rates, larger expenditures, and lower cardiac complication rates.

In the U.K. where the English National Health Service (NHS) reforms from 2002 to 2008 encouraged hospitals to compete on non-price services and allow patients to choose hospitals for care (Cooper et al., 2011), a study by Cooper et al. (2011) applies a DID approach to examine the impact of whether such reforms result in better hospital quality. Cooper et al. (2011) use patient-level data of Hospital Episodes Statistics (HES) from 2002 to 2008 and 30-day AMI mortality rates as quality measures. In addition to logged hospital numbers, Cooper et al. (2011) estimate competition mainly with HHI based on actual patient flows and HHI based on predicated patient flows, which is similar to the one used in the study of Kessler and McClellan (2000) mentioned above. Cooper et al. (2011) find that hospital competition enhances quality of care as the 30-day mortality rates reduce faster in more competitive fixed-priced markets after the introduction of patient choice in 2006. Moreover, Cooper et al. (2011) indicate that the improvements in both the annual number of AMI treated and the mortality rates from 2002 to 2006 are a result of the growing use of new technology in AMI treatment as well as enhancements in public health. In conclusion, Cooper et al. (2011) estimate that the reforms lead to approximately 300 fewer deaths per year.

Similarly, Gaynor et al. (2010) investigate how the policy changes in the UK's NHS in 2006 led to increased hospital competition. They also investigate how this affects clinical quality by using a DID approach and referring it to hospital administrative data of 162 acute hospitals for financial year 2003 and 2007. They use four sets of mortality rates such as 28-day AMI inpatient mortality rates, 30-day AMI (on or after discharge) mortality rates, 28-day all-cause inpatient mortality rates, and 28-day all-cause excluding AMI inpatient mortality rate quality measures. HHI based on patient flows to each hospital is used as a measure of market structure. Gaynor et al., (2010) find a significant relationship between market concentration and clinical quality and hospitals in competitive markets have substantially lower mortality rates than those located in less competitive markets after the reform. As such, Gaynor et al., (2010) conclude that increased competition leads to better patient outcomes and hospitals in more competitive markets are more efficient in managing resources to enhance patient outcomes.

More evidence that competition leads to better quality is shown in a UK based study by Bloom et al. (2010) that also finds competition improves quality of care. Bloom et al. (2010) examine the impact of competition on hospital management quality and hospital performance in English public hospitals using data mainly from the UK Department of Health for 2005-2006 and hospital surveys on hospital management practices conducted in 2006. Bloom et al. (2010) use the number of public hospitals within a certain geographical area as a competition measure and 28-day AMI mortality rates as a measure of quality. Bloom et al. (2010) conclude that higher competition improves both clinical and management quality as AMI mortality rates are reduced by 9.7 %, and staff satisfaction rises by 0.45 of the standard deviations.

Reduced quality

In the U.S., policy reforms such as the Health Care Reform Act (HCRA) in New Jersey in 1992 have raised concerns about the effect of the new HCRA on quality of care as the reform in New Jersey not only allowed price competition among hospitals, but also substantially reduced subsidies in medical care for the uninsured (Volpp et al., 2003). Volpp et al., (2003) investigate the impact of price competition on the quality of care for uninsured AMI patients, using the DID approach and hospital discharge data in New Jersey and New York to compare the changes in AMI outcomes from the period before the reform (from 1990 to 1992) to that after the reform (from 1994 to 1996). The researchers choose New York where there is no change in hospital price regulation during that period for comparison purposes. Volpp et al., (2003) use the 30-day AMI mortality rate as the study's primary outcome measure, and they find that the AMI mortality rate for the uninsured in New Jersey raised 3.7 to 5.2 percentage points in comparison to that of New York from the pre-reform period to the post-reform period. In conclusion, Volpp et al., (2003) indicate that price competition and reduced subsidies as a result of the market-based reform, decrease the quality of care for the uninsured AMI patients in New Jersey.

Another U.S. based study also finds negative impact. Using a technique in measuring competition similar to that of Kessler and McClellan (2000), Gowrisankaran and Town (2003) measure the impact hospital competition has on the mortality rates for five different payer groups of patients with AMI or pneumonia in Los Angeles County, California between 1989 and 1993. Gowrisankaran and Town (2003) utilize hospital morality rates for pneumonia and AMI as measures of hospital quality and HHI based on predicated patient choice as competition measures for all different payer groups of patients. In contrast to the finding of Kessler and McClellan (2000), whose results demonstrate that hospital competition enhances quality of care for Medicare patients, Gowrisankaran and Town (2003) find that competition among hospitals reduces hospital quality for Medicare patients while it improves quality for HMO patients. Although Gowrisankaran and Town (2003) suggest that such result may be due to the small Medicare margins or hospitals' deviations from profit-maximizing behavior. However, Gaynor (2006) indicates that during this period, there was a great increase in the entry of hospitals specializing only in heart disease treatment, thus the margin must be substantial to explain such an entry. Furthermore, Gaynor (2006) hypothesizes that such differences in findings could be due to the differences in the instrumentation approaches that the researchers employ.

Similarly, a U.K. based study done by Propper et al. (2004) finds that hospital competition reduces quality of care. Following the National Health Service (NHS) reforms in the 1990s that lead to payer-driven competition among hospitals, Propper et al. (2004) utilize hospital level data between the financial years of 1995/6 and 1997/8 to examine the impact of hospital competition on quality of care. The researchers use 30-day AMI inpatient morality rates as primary quality indicators. To measure competition, Propper et al. (2004) apply two measures of competition based on potential patient travel: the first measure of competition is the number of competitors in each hospital's catchment area and the second measure of competition is the share of each hospital's catchment population that can go to the other 20 hospitals within the same service area. Propper et al. (2004) conclude that hospital competition does not enhance quality of care as hospitals in more competitive areas result in higher mortality rates. However, Propper et al. (2004) indicate that as their study is the first to examine the impact of hospital competition on quality in the U.K., they recommend further confirmation by other studies with patient level data or longer time series data.

The above studies provide some evidence on the association of hospital competition with quality of care. However, their findings vary. This may be due to a number of reasons such as differences in methodology, sample size, patient groups, and locations. Therefore, the study uses meta-analysis to investigate the underlying impact of hospital competition, using summary data of the studies identified in the literature search.

METHODS

Study identification

This study is a systematic review and uses meta-analysis to combine results from various studies to obtain an overall outcome. For the preliminary research, computer-assisted research is conducted through PubMed, using keywords such as *hospital competition* or *quality* or *hospital competition and quality* or *competition and quality of care*. Boolean operators (NOT, AND, and OR) are also used in the search process (McGrath et al., 2012; Pan, L.M., 2013). Google search is also used to identify unpublished studies. Moreover, unpublished research unavailable on a particular website is obtained by directly contacting the relevant organization such as U.S Department of Justice. Furthermore, the references lists in the retrieved research reports are examined and then a computerized search through the databases was conducted to obtain relevant papers not found in the initial search. The titles and abstracts of the studies generated from the preliminary research are examined to determine their relevance. The majority of the studies are published in journals, while some of them are unpublished studies, working, or discussion papers from professional associations such as CPB Netherlands Bureau for Economic Policy Analysis, Centre for Economic Performance (CEP) in London School of Economics and Political Science, the Centre for Market and Public Organization (CMPO) in Bristol Institute of Public Affairs, and National Bureau of Economic Research (NBER). The second stage review includes analyzing research questions and aims, data, methodology, and results of the studies identified in the preliminary search to determine suitability.

Selection criteria

The studies selected from the search are based on a variety of criteria. First, the research includes published and unpublished studies written in English. Second, studies are excluded if their topics are unrelated to hospital competition associated with quality of care. Third, studies which are descriptive, do not use multivariate analysis to control for confounding factors, or do not provide sufficient information such as methodology and data are excluded. Fourth, types of competition other than hospital competition are excluded. Fifth, because the 30-day AMI mortality rate is the mostly commonly used quality measure, this meta-analysis employs this indicator to measure the quality of care and thus studies that do not use this quality measure are excluded. As the meta-analysis aims to provide updated observations based on recent studies, studies conducted before the year 2000 are excluded. In addition, data and information from all studies selected are independently reviewed and extracted.

Evaluation of effect

Comprehensive Meta-Analysis version 2.0 is used to conduct meta-analysis (Borenstein et al., 2009). Measure of effect size, I^2 test, meta-regression to find sources of heterogeneity, tests for publication bias, sensitivity analysis and cumulative analysis are performed. The mean effect size is estimated by coefficient and standard error with *P* values less than 0.05 which is considered statistically significant. A negative coefficient indicates that hospital competition results in a reduction in 30-day AMI inpatient mortality rates, suggesting competition leads to better quality of care, and vice versa. To test for heterogeneity, both the fixed effect and random effects models are used. While the fixed effect model assumes that the real effect size is the same for all studies, the random effects model assumes that the real effect size differs across studies (Borenstein, 2009). According to Borenstein (2009), selection of the fixed effect model should be based on two conditions: variables that can impact the outcome are identical across the studies and the goal of the meta-analysis is to obtain one common effect size for the population defined (Ibid). However, if the goal of the meta-analysis is to assess the mean effect in various studies, the random effects model should be used (Ibid). Furthermore, as there is heterogeneity among the studies, the random effects model is employed to assess the pooled effect.

Evaluation of heterogeneity and sources

Heterogeneity is the variation in outcomes between studies (StatsDirect, 2016). Heterogeneity is measured by Cochran's Q-statistics and the I^2 test. Cochran's Q-statistics is calculated as the weighted sum of squared differences between each study's effect estimate and the overall effect estimate (Huedo-Medina et al., 2006; StatsDirect, 2016). It provides a p-value of 0.05 as a cut-off for significance; however, Cochran's Q-statistics has low power at detecting heterogeneity (Higgins et al., 2003). Thus this study also applies I^2 statistic to test for heterogeneity. The I^2 statistic estimates the percentage of total variation across studies that is due to heterogeneity rather than chance (Flecher, 2007; Higgins et al., 2003; MedCalc, 2016). A result of 0% from the I^2 test depicts non-existence of heterogeneity while a result of 100% indicates the highest level of heterogeneity (Li et al., 2016). As shown in the result section, the I^2 test is above 50% which suggests that the total observed variation is a result of heterogeneity (Li et al., 2016; Warrier et al., 2015). The potential sources of heterogeneity or moderators in CMA 2.0, were assessed by meta-regression analysis. The meta-regression method applies regression analysis to investigate the impact of selected variables on the effect size (Haidich, 2010). Age of patients, sample size of hospitals, study year, and year of publication are identified as potential sources of heterogeneity. As study period length varies from study to study, the median year is used for each study in the meta-regression. If the mean age is provided, it is used in the meta-regression. Otherwise, the median age is applied.

Evaluation of publication bias, Sensitivity analysis, cumulative analysis

To examine publication bias in the meta-analysis, a funnel plot, the Rosenthal fail-safe N method, Begg and Mazumdar Rank Correlation Test and Egger's regression test are used. Publication bias arises when research with significant results are likely to be published (Gordis, 2009). If there is publication bias in the sample of studies included in the meta-analysis, the validity of the results from the meta-analysis is threatened (Rothstein et al., 2005). The funnel plot which is used for detecting publication bias or heterogeneity, is a scatter plot of the effect estimate against a measure of study size (Azsures-Cabrera and Higgins, 2010). If publication bias is present, the funnel plot is expected to have an asymmetric shape (Haidich, 2010). Moreover, the Rosenthal fail-safe N method computes a combined p-value for all studies in the meta-analysis and then finds the number of additional unpublished studies with null results to make the results of a meta-analysis statistically insignificant (Borenstein, 2005; Cochrane Handbook, 2016). The Begg and Mazumdar Rank Correlation test computes the inverse correlation between study size and effect size to test for publication bias (Ibid). Similar to the Rosenthal fail-safe N method, this test reports two-sided *p*-value and if the *p*-value is significant (p-value < 0.05), there is publication bias (Rothstein et al., 2005). Furthermore, Egger's test uses a simple linear regression to predict y (the actual values of the effect size of each study divided by its standard error) by using their precision (the inverse of the standard error) to test that the intercept that captures the bias is significantly different from zero (Thornton and Lee, 2000). If the *p*-value from this test is significant (p-value < 0.05), then there is publication bias.

Sensitivity analysis tests the stability of the pooled effect estimate (Ressing et al., 2009). It is performed by deleting each study one by one to examine if any studies have a significant effect on the pooled outcome (Warrier et al., 2015). Finally, the studies are sorted chronologically based on publication year, and a cumulative analysis is conducted to investigate how the estimated effect size may have changed over time (Borenstein et al., 2009). It depicts the stability or instability of the effect over time (Tanner-Smith, 2013).

Results

Included studies

575 studies are located from databases and of these, 102 are identified for further screening as their titles or abstracts seem to meet the selection criteria. An additional 10 papers are identified from the references. Based on the selection criteria, only 11 studies are included for this meta-analysis. As one study (Gowrisankaran and Town, 2003) uses two different populations to examine the identical effect and provides separate results for the two populations, the two results of this study are treated as two separate studies. As such, 11 studies are included in the meta-analysis. Table 3.1 provides summary data of the studies that are selected in the analysis.

Association of hospital competition with quality of care

Pooled effect

The pooled effect of hospital competition on quality of care is reported by all of the 11 studies that are included in the analysis. This is illustrated in the forest plot (Figure 3.1). The results of the meta-analysis suggest that hospital competition reduces quality of care, but the overall effect is relatively insignificant from a statistical perspective (Point estimate = 0.008, 95% CI = -0.004 ~ 0.020, $P > 0.05$) (Figure 3.1). The forest plot in Figure 3.1 depicts the estimated point estimate and the 95% confidence intervals for each study. It shows that the point estimates of the correlation coefficient range from -0.313 to 0.330 and the 95% confidence intervals include 0.

Individual studies

If the 95% confidence interval for the estimated difference among the groups does not include 0, then the effect is a statistically significant one ($P < 0.05$) (Lang and Secic, 2006). Among the eleven studies selected in this meta-analysis, the majority of the studies have 95% confidence intervals that do not include 0. There are eight studies that indicate a statistically significant association between hospital competition and quality of care ($P<0.05$) (Figure 3.1). Among these eight studies, four studies demonstrate that hospital competition lowers AMI mortality rates (i.e. Bloom et al., 2010, Cooper et al., 2011, Gaynor, 2010; Gowisankaren and Town, 2003

(HMO)), whereas the other four indicated the opposite effect (i.e. Gowisankaran and Town, 2003 (Medicare), Mutter et al., 2008, Propper et al., 2004, Propper et al., 2008).

Heterogeneity and meta-regression

Moreover, the forest plot illustrates the presence of heterogeneity as there is a wide spread of results and many 95% confidence intervals do not overlap (Figure 3.1). To measure heterogeneity statistically, the I^2 statistic is performed, which indicates a percentage of 81.50%, suggesting high heterogeneity ($I^2 = 81.50\%$) (Figure 3.1). As the studies vary and there is evidence of heterogeneity (Point estimate = 0.008, 95% CI = -0.004 ~ 0.020, $P > 0.05$), the random-effects model is used in this meta-analysis (Figure 3.1). Meta-regression is performed to investigate potential sources of heterogeneity such as year of publication, age, sample size, and study year and each source's relationship with the outcome. The results of meta-regression indicate that after adjusting for the three potential sources of heterogeneity, only year of publication appears to be the crucial factor of heterogeneity (Slope = -0.00207, Intercept = 4.13648, $P < 0.05$) (Figure3.2), while age, study year, and sample size do not show significant results (Age: Slope = -0.00074, Intercept = 0.05428, $P > 0.05$; Study year: Slope = -0.00888, Intercept = 17.75239, $P > 0.05$; Sample size: Slope = 0.00002, Intercept = -0.00079, $P > 0.05$) (Figure 3.3, 3.4, 3.5). The meta-regression results indicate that studies that are published more recently depict better quality of care (or lower AMI mortality rates) (Figure 3.2). Such result indeed reflects the current situation in the healthcare market where medical technology has become more advanced compared to the past. Therefore, mortality rates are likely to be lower because of the improved quality of care resulted from the continuous advancement in medical practices, technology, and prevention techniques over time (Bijlsma et al., 2010). In addition to improvement in medical technology and prevention techniques, policy reforms that help improve healthcare quality may have also improved hospital quality (Ibid).

Sensitivity analysis

The sensitivity analysis is conducted to determine if any study has impact on the pooled effect (Lang and Secic, 2006). The result of sensitivity analysis indicates that no particular study has significant impact on the pooled association of hospital competition and quality of care (Figure 3.6).

Publication bias

Publication bias is not presented as determined through visual inspection of the funnel plot, which is symmetrical (Figure3.7). Also, the Classic fail-safe N tests indicate that there is no significant publication bias ($P > 0.05$) (Table 3.2). The Begg and Mazumdar rank correlation test depictes insignificant results (Kendall's tau = -0.09091, 1 tailed $P > 0.05$, 2-tailed $P > 0.05$). Moreover, the Egger's regression further confirms non-existence of publication bias (Intercept = 0.68047, 95% CI = -0.81279 ~ 2.30324, 1-tailed and 2 tailed $P > 0.05$).

Cumulative meta-analysis

Cumulative meta-analysis is performed by sorting the studies chronologically based on year of publication from the earliest to the most recent to identify how the evidence on the effect of hospital competition on quality of care has shifted over time (Borehein et al., 2009). Figure 3.8 illustrates that the first study on HMO patients done by Gowrisankaran and Town (2003) depicts statistically significant evidence on the association of hospital competition and quality of care ($P < 0.05$). It is the first and the only study among the studies selected that suggests a positive effect of hospital competition on reducing mortality rates. After adding their study on Medicare patients, the point increases substantially and changes to the opposite direction, suggesting that hospital competition increases mortality rates. The studies that are conducted afterwards all demonstrate the opposite effect of hospital competition on mortality rates with statistically insignificant results (P > 0.05). However, the magnitude of the impact of hospital competition on mortality rates decreases over time. The precision of the estimated outcome improves since the 95% confidence intervals become narrower as the data accumulates (Lang and Secic, 206). Overall, the cumulative analysis demonstrates a stable result. Furthermore, the impact of hospital competition on mortality rates becomes less detrimental over time which may possibly be due to differences in methodologies between the studies included and the improvement in medical technology which helps decrease mortality rates as illustrated in the section on heterogeneity and meta-regression.

Discussion

In this meta-analysis, the examination of the pooled effect of hospital competition on quality of care was based on the selected studies in the context of Western countries such as U.S., UK, Netherlands, and Australia. The results from the meta-analysis random-effects calculation suggest that hospital competition relatively increases AMI mortality rates, although this association is statistically insignificant ($P > 0.05$). The results from the meta-analysis indicate that among the eleven studies, there are only eight that depict a statistically significant association of hospital competition and quality of care. While half of the studies (one U.S. and three UK studies) depict that hospital competition leads to better quality (lower mortality rates), the other half (two UK and two U.S. studies) indicate the opposite. Due to the variety of contexts, the mixed results from the meta-analysis on the association between hospital competition and quality of care may be predictable. The results from the studies in markets where firms set prices have been predicted by the economic theory that competition in these markets leads to either improved or decreased quality (Gaynor, 2006). However, the results of studies done for regulated markets are not consistent with the economic theory for fixed-price markets. Gowrisankaran and Town's study (2003) finds that hospital competition increases the 30-day AMI mortality rates for Medicare patients. Gowrisankaran and Town (2003) explain that the negative impact of hospital competition on quality could be due to either the low margins of Medicare patients or hospitals' deviation from profit-maximizing behavior. However, due to the complicated nature of the health care market, the economic theory on the association between competition and quality may not be applicable as it is not clearly evident in the healthcare sector (Glick et al., 2015).

There are a number of reasons for the mixed results on the association between hospital competition and quality of care more distinctly. First, the variation in study methodology may have contributed to the inconsistent results on the association between hospital competition and quality of care (Bevan and Skellern, 2011; Glick et al., 2015). The studies employed various methods for measuring HHI based on the predicated flow of patients and the actual flow of patients, the number of hospitals, or the distance to the closest competitors as illustrated in the literature review section. However, these approaches may not have accurately captured the market size of a hospital. Hospital quality could be associated with market size and distance to another hospital, so there can be differences between urban and rural areas (Cooper et al., 2011). Second, the nature of hospital business is too complicated to use one single quality measure to assess the overall quality of care of a hospital. As one single quality indicator may only relate to a particular condition, other aspects of quality in a hospital may be overlooked (Gaynor, 2006). As such, when sufficient data and research become available, future meta-analysis focusing on other quality and competition measures to estimate the pooled effect of hospital competition on hospital quality will be beneficial.

In consideration of the possible limitations of this study, it is important to recognize that because of the limited availability of studies employing identical quality measures, only eleven studies were examined. This can be seen to limit its representativeness. Future research to include more studies would help substantiate the results find in this study.

Conclusion

The differences in study design and methodology of studies on the association of hospital competition and quality of care may account for the inconsistent findings. Based on the findings from this study, hospital competition slightly increases AMI mortality rates, although such negative impact is statistically insignificant. However, such negative impact can be expected to lessen over time as medical technology, practices, and techniques continue to improve. Indeed, this downward trend is consistent to the findings in prior research (Bijlsma et al., 2010; Proper et al., 2003). Furthermore, in view of the complicated nature of the healthcare market, when assessing the effect of hospital competition on quality of care, different measures for market structure and quality should be taken into account.

Table 3.1 Summary data of the included studies

Study	Time period	Geographic Area	Quality measure	Competition measure	Competition effect on quality
Bijlsma et al. (2010)	2004-2008	Netherlands	18 quality indicators including 30-day AMI mortality rates	Number of competitors, HHI	Mixed effect
Bloom et al. (2010)	2005-2006	U.K.	28-day AMI mortality rates	Number of competitors	Increased quality
Cooper et al. (2011)	2002-2008	U.K.	30-day AMI mortality rates	HHI	Increased quality
Gaynor, 2010	2003-2007	U.K.	4 mortality rates including 30-day AMI mortality rates	HHI	Increased quality
Gowrisankaran and Town (2003)	1989-1993	California, U.S.	30-day AMI Mortality rates (HMO)	HHI	Increased quality
Gowrisankaran and Town (2003)	1989-1993	California, U.S.	30-day AMI Mortality rates (Medicare)	HHI	Reduced quality
Mutter et al. (2008)	1997	All states in U.S.	38 quality indicators, 30-day AMI mortality rates	12 competition measures including number of hospitals and HHI	Mixed effect but decreased quality for AMI patients
Palagkaraya and Yong (2013)	2000-2005	Australia	30-day AMI mortality rates	HHI and the number of hospitals	Mixed effect but reduced quality for AMI patients
Propper et al. (2003)	1991-2000	U.K.	30-day AMI Mortality rates	Number of competitors	Reduced quality
Propper et al. (2004)	1995-1998	U.K.	30-day AMI Mortality rates	Number of competitors	Reduced quality
Propper et al. (2008)	1991-2000	U.K.	30-day AMI Mortality rates	Number of competitors	Mixed effect but decreased quality for AMI patients

Figure 3.1 Forest Plots of the effect of hospital competition on quality of care

Study name	Subgroup within study	Statistics for each study						
		Point estimate	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Gowrisankaran and Town, 2003 (HMO)	HMO	-0.230	0.100	0.010	-0.426	-0.034	-2.300	0.021
Gowrisankaran and Town, 2003 (Medicare)	Blank	0.330	0.110	0.012	0.114	0.546	3.000	0.003
Propper et al., 2003	Blank	0.010	0.006	0.000	-0.002	0.022	1.574	0.116
Propper et al., 2004	Blank	0.120	0.040	0.002	0.042	0.198	3.000	0.003
Mutter et al., 2008	Blank	0.058	0.027	0.001	0.006	0.110	2.176	0.030
Propper et al., 2008	Blank	0.006	0.003	0.000	0.001	0.011	2.400	0.016
Bijlsma et al., 2010	Blank	0.018	0.085	0.007	-0.149	0.185	0.212	0.832
Bloom et al., 2010	Blank	-0.150	0.065	0.004	-0.278	-0.022	-2.294	0.022
Gaynor, 2010	Blank	-0.313	0.116	0.013	-0.540	-0.086	-2.698	0.007
Cooper et al., 2011	Blank	-0.001	0.001	0.000	-0.002	-0.000	-2.800	0.005
Palangkaraya and Yong, (2013)	Blank	0.268	0.206	0.042	-0.134	0.671	1.306	0.192
		0.008	0.006	0.000	-0.005	0.020	1.215	0.224

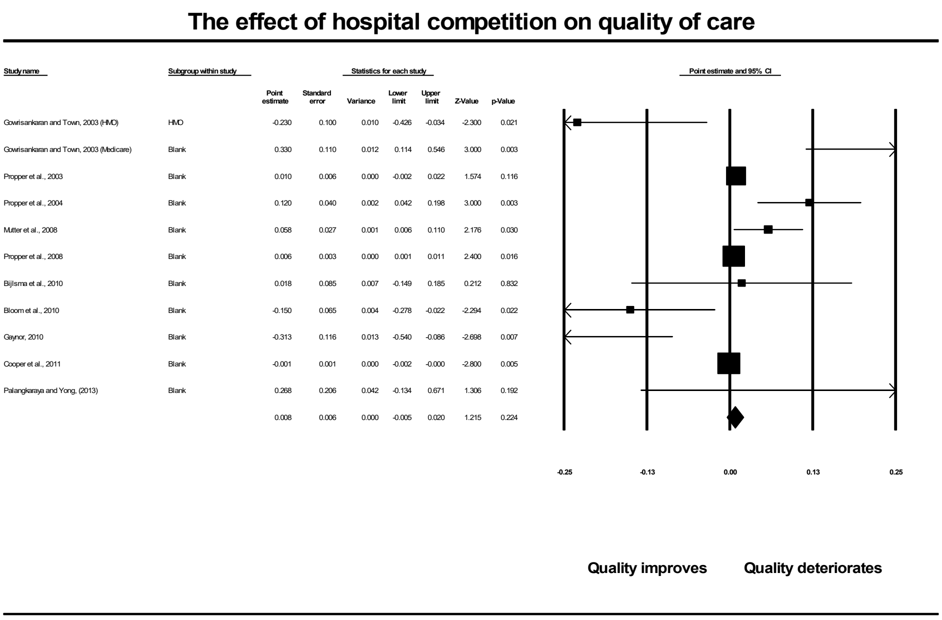


Figure 3.2 Meta-regression (publication year)

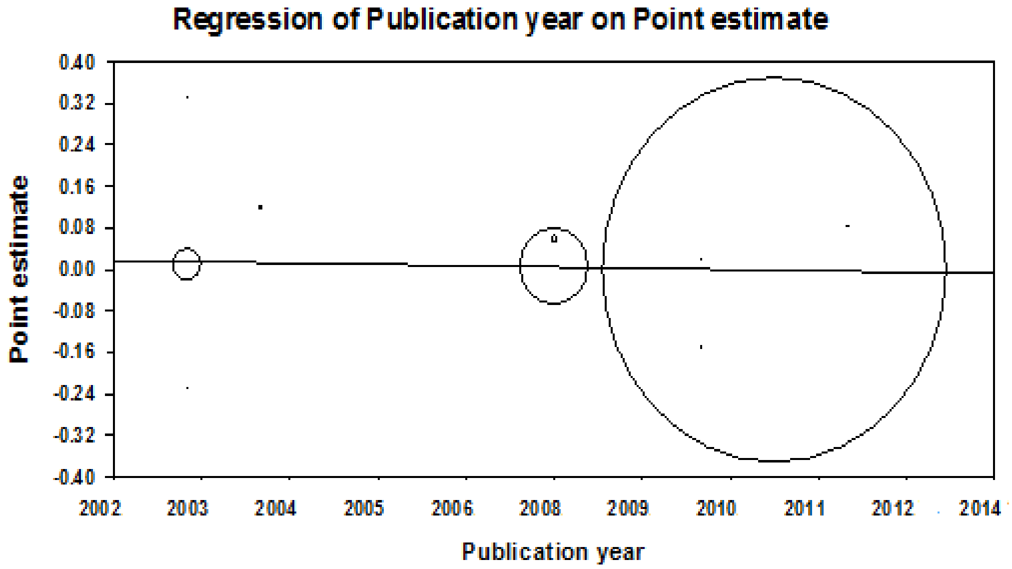


Figure 3.3 Meta-regression (age)

Figure 3.4 Meta-regression (study year)

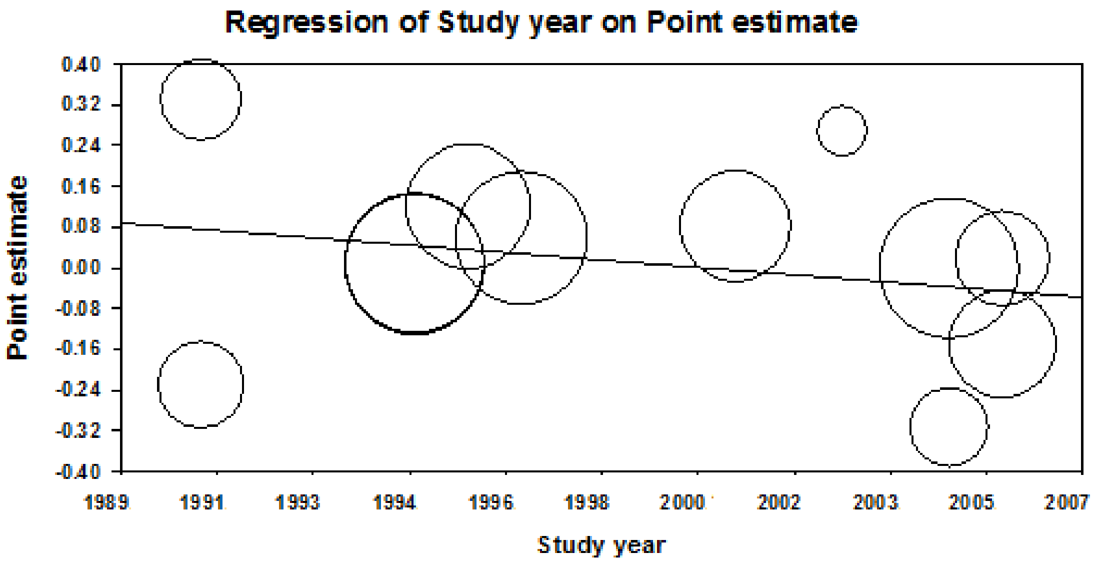


Figure 3.5 Meta-regression (sample size)

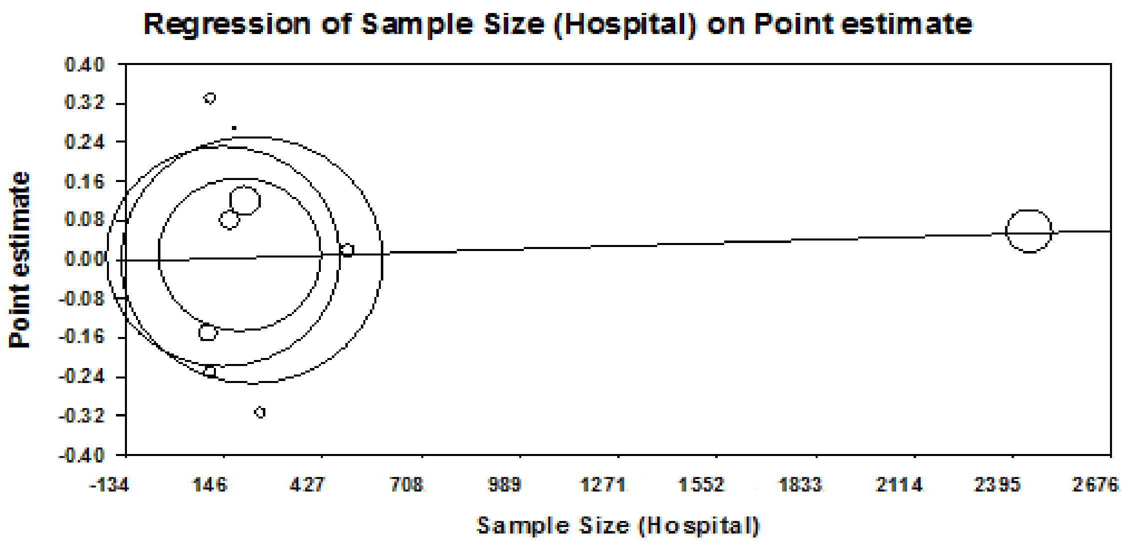


Figure 3.6 Sensitivity Analysis

Study name	Subgroup within study	Statistics with study removed						
		Point	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Gowrisankaran and Town, 2003 (HMO)	HMO	0.008	0.006	0.000	-0.004	0.020	1.365	0.172
Gowrisankaran and Town, 2003 (Medicare)	Blank	0.006	0.006	0.000	-0.005	0.018	1.077	0.282
Propper et al., 2003	Blank	0.007	0.008	0.000	-0.008	0.022	0.969	0.333
Propper et al., 2004	Blank	0.005	0.006	0.000	-0.007	0.016	0.829	0.407
Mutter et al., 2008	Blank	0.005	0.006	0.000	-0.007	0.017	0.810	0.418
Propper et al., 2008	Blank	0.014	0.014	0.000	-0.014	0.042	0.993	0.321
Bijlsma et al., 2010 (A20)	Blank	0.008	0.006	0.000	-0.005	0.020	1.201	0.230
Bloom et al., 2010	Blank	0.009	0.006	0.000	-0.003	0.021	1.438	0.150
Gaynor, 2010	Blank	0.008	0.006	0.000	-0.004	0.020	1.368	0.171
Cooper et al., 2011	Blank	0.017	0.014	0.000	-0.012	0.045	1.158	0.247
Palangkaraya and Yong, (2013)	Blank	0.007	0.006	0.000	-0.005	0.020	1.178	0.239
		0.008	0.006	0.000	-0.005	0.020	1.215	0.224

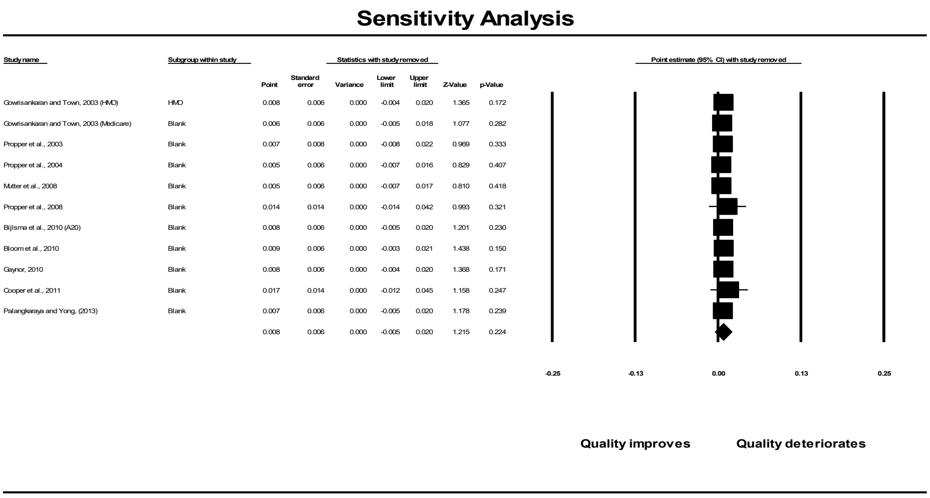


Figure 3.7 Publication bias

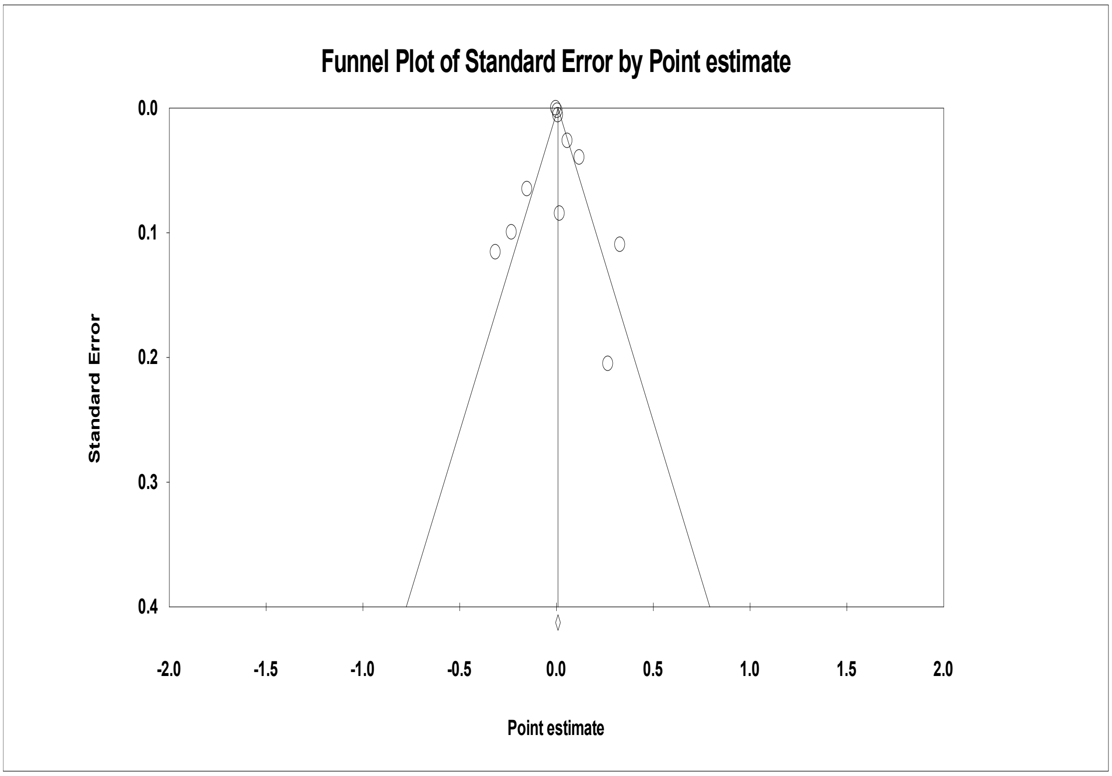
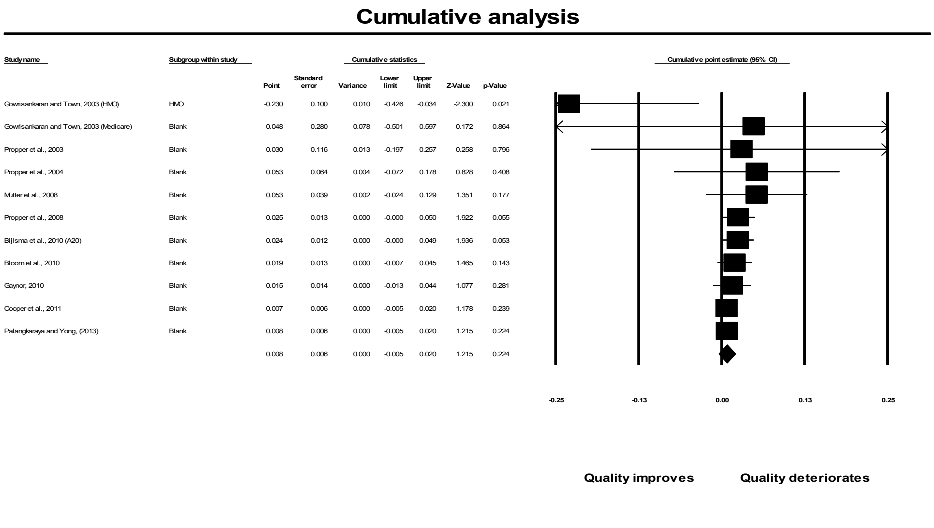


Figure 3.8 Cumulative analysis

		Point	error	Variance	limit	limit	Z-Value	p-Value
Gowrisankaran and Town, 2003 (HMO)	HMO	-0.230	0.100	0.010	-0.426	-0.034	-2.300	0.021
Gowrisankaran and Town, 2003 (Medicare)	Blank	0.048	0.280	0.078	-0.501	0.597	0.172	0.864
Propper et al., 2003	Blank	0.030	0.116	0.013	-0.197	0.257	0.258	0.796
Propper et al., 2004	Blank	0.053	0.064	0.004	-0.072	0.178	0.828	0.408
Mutter et al., 2008	Blank	0.053	0.039	0.002	-0.024	0.129	1.351	0.177
Propper et al., 2008	Blank	0.025	0.013	0.000	-0.000	0.050	1.922	0.055
Bijlsma et al., 2010 (A20)	Blank	0.024	0.012	0.000	-0.000	0.049	1.936	0.053
Bloom et al., 2010	Blank	0.019	0.013	0.000	-0.007	0.045	1.465	0.143
Gaynor, 2010	Blank	0.015	0.014	0.000	-0.013	0.044	1.077	0.281
Cooper et al., 2011	Blank	0.007	0.006	0.000	-0.005	0.020	1.178	0.239
Palangkaraya and Yong, (2013)	Blank	0.008	0.006	0.000	-0.005	0.020	1.215	0.224
		0.008	0.006	0.000	-0.005	0.020	1.215	0.224



CHAPTER 4:

EFFECTS OF HOSPITAL MERGER, OWNERSHIP, LEVEL, AND LOCATION ON QUALITY OF CARE: EVIDENCE FROM TAIWAN

Abstract

Background: As there seems to be limited current research on quality of care in the context of Taiwan, this study aims to add to the limited research and to serve as a pilot study using the seven quality measures compiled by MOHW to examine the association of hospital merger, ownership, level, location and quality of care. As research indicates that hospital size and hospital competition affect quality of care (Brownlee and Saini, 2014; Whiet et al., 2014; Dash and Meredith, 2010), this study also investigates the association between hospital size, competition and quality of care.

Methods: The study uses hospital level data between 2011 and 2014 from the Ministry of Health and Welfare. The study applies the generalized linear mixed model (GLMM) to investigate the association between hospital factors such as merger, ownership, level, location and quality in terms of the seven process measures provided by the Ministry of Health and Welfare.

Results: The study finds that hospital ownership, level, and location are significantly associated with quality in terms of the process measures ($P < 0.05$). However, the study finds insignificant and mixed relationship between hospital competition, merger and quality ($P > 0.05$). The study finds significant association between the number of acute beds and quality ($P < 0.05$). Larger hospitals depict weaker quality in terms of certain measures as shown in the results section. Furthermore, the evidence shows that public hospitals have poorer quality.

Conclusion: The study finds hospital ownerships, levels, and locations are associated with quality in terms of certain process measures. However, the study finds insignificant and mixed relationships between hospital competition, mergers and quality. The study finds significant association between the number of acute beds and quality. Larger hospitals depict weaker quality in terms of certain measures shown in the results section. Furthermore, the evidence shows that public hospitals have poorer quality. Policy attention to improve hospital quality in public hospitals and to rectify the overcrowding problem in medical centers and regional hospitals is crucial.

Introduction

Taiwan implemented the National Health Insurance program in 1995, and launched the global budget program with a fixed-budget polity in 2002. Since then, hospitals have experienced unprecedented pressure as the reimbursement payments from BNHI decrease while at the same time their costs increase each year (Medical Information Science Reference, 2015). To sustain their operations, hospitals have to retain costs while maintaining high quality of care. As a result, many hospitals have exited the market and the number of hospitals has reduced by 63% (Ministry of Health and Welfare, 2015). However, this reduction of hospitals is mainly in public hospitals (Huang et al., 2012). On the other hand, the number of private hospitals has increased by 2.3 times during the same period. Consequently, the total number of hospital beds has grown about 33% from 1995 to 2013 (Ministry of Health and Welfare, 2015). In addition to these two major medical reforms, the Taiwan government merged several regional hospitals in Northern and Southern Taiwan in 2003, 2004, and 2005. Indeed, one of these mergers even created the largest public hospital in Northern Taiwan. However, based on the author's research, the reform in merging the regional hospitals has not led to substantial growth in the research of hospital mergers or competition. In the U.S., while many studies investigate the effects of hospital mergers associated with costs and price, there are only a few studies that examine the effects of hospital mergers associated with quality of care. However, the findings of the studies in general demonstrate mixed and inconsistent results on the association of hospital mergers and quality of care. The results of these studies are discussed in the literature review section.

Moreover, while there are many factors that can contribute to the quality of care of hospitals, research on the association between hospitals factors (such as ownership, levels, technology, the number of competitors, occupancy rate, hospital scale, and locations) and quality of care is also very sparse in Taiwan. This may be due to the unavailability of hospital and patient data, and the limited access to it. In order to monitor and improve the quality of care in local hospitals, the Ministry of Health and Welfare has started compiling and publishing information on hospital quality in terms of the various process care measures as well as financial statements of local hospitals in recent years. As such, information on quality of care of hospitals in Taiwan can be visible to patients, and consequently hospitals may focus more on improving their quality of care.

This chapter assesses the association between hospital ownership, merged/non-merged, level, location and quality of care using on hospital level data. Also, it investigates the differences in quality of care among the hospitals based on hospital size (measured by the number of acute beds) and competition (measured by the number of hospitals in the same marketplace). This study aims to add to the limited research pertaining to quality of care in the context of Taiwan. It is also a pilot study to assess the association between hospital merger, ownership, levels, locations and quality and care in Taiwan, using the seven quality measures published by

MOHW. Moreover, it aims to build a foundation for further analyses on quality of care with a broader set of quality measures.

This chapter is organized as follows: The next two sections provide literature review on quality of care associated with hospital mergers and literature review on the relationship of hospital ownership, level, location and quality of care. The subsequent sections then present the methods, data, results, discussion, and conclusion.

Literature review on quality of care associated with merger

Ho and Hamilton (2000) apply Cox's proportional hazard and linear probability models to examine the impact of hospital mergers and acquisitions on quality of inpatient care. The researchers use hospital data from the AHA Annual Survey of Hospitals from 1991 to 1995 and patient-level data from the California Office of Statewide Health Planning and Development (OSHPD) discharge data between 1991 and 1996. Ho and Hamilton (2000) use inpatient mortality, 90-day readmission rates, and early discharge of normal newborns within 48 hours as quality measures. Ho and Hamilton (2000) report that there is no negative effect of hospital mergers and acquisitions on inpatient mortality for heart attack or stroke patients; however, given the small sample size, the impact may be too small to be noticeable. In contrast, Ho and Hamilton (2000) find that hospital mergers increase the probability of 90-day readmission rates for heart attack patients by 1.7 percentage points, while acquisitions of independent hospitals increase the readmission rates by 0.9 percentage points, and acquisitions of systems increase the rates by 0.7 percentage points. Ho and Hamilton (2000) indicate that acquisitions can negatively impact quality of care as the probability of readmission rates for heart attack patients increases in all three types of mergers. They also find that while mergers of independent hospitals in a competitive market decrease the probability of early discharge of newborns by 1.7 percentage points, acquisitions of a system hospital by another system raise the probability of early discharge of newborns by 3.7 percentage points (Ho and Hamilton, 2000). Ho and Hamilton (2000) conclude that hospitals in higher concentrated markets seem to result in lower quality after consolidation, as shown in the increase in early discharge for newborns in some hospital acquisitions.

Cuellar and Gertler (2003) identify 1,377 hospitals from 1995 to 2000 in four states (Arizona, Florida, Massachusetts, and Wisconsin) from the AHA's Annual Survey of Hospitals. They apply multivariate regression models to examine the impact of system consolidation on quality of care using measures such as inpatient mortality rate, overused procedures rate, and adverse patient safety rate. The authors report that while overused procedures rate decreases by 1.2 percentage points, avoidable inpatient mortality and inadequate patient safety rates do not change. Cuellar and Gertler (2003) conclude that system consolidation has little or no effect on inpatient quality of care, and even if hospitals gain higher prices, they do not use this to enhance their quality of inpatient care.

The study done by Capps (2005) also demonstrates that hospital mergers have little effect on quality of care. Utilizing the data from AHA and Medicare Cost

Reports in New York State between 1995 and 2000 and the quality indicators from Agency for Healthcare Research and Quality (AHRQ), Capps (2005) applies the DID approach to estimate the effects of hospital mergers on quality of care in 25 merging hospitals. Capps (2005) uses two approaches to select the control group: use of non-merging cardiac hospitals as control group and use of propensity scoring similar to the method used in the study of Dranove and Lindrooth (2003) to select control group of non-merging hospitals that are similar to merging hospitals. The results derived from comparing to two different control groups of non-merging hospitals demonstrate that hospitals mergers do not improve quality of care. However, Capps (2005) indicates that the method of selecting control groups may affect the statistical significance of the results. As such, Capps (2005) suggests future analyses built on a larger sample of merging hospitals and control groups may help derive more reliable conclusions.

Romano and Balan (2010) apply DID analysis to investigate the changes in quality of care after a merger, using data from the Illinois Department of Public Health Universal Dataset from 1998 to 2003. Unlike other studies, Romano and Balan (2010) examine one particular merger case, the acquisition of Highland Park Hospital (HPH) by Evanston Northwestern Healthcare hospital system (EH) near Chicago. Romano and Balan (2010) use quality measures such as Inpatient Mortality Indicators (IQIs) and the Patient Safety Indicators (PSIs) to analyze patient outcomes after the merger. They compare the rates of the merged hospitals with a set of control hospitals in the Chicago area. Romano and Balan (2010) find while most of the quality indicators show statistically insignificant or mixed results, some depict significant deterioration. For instance, the researchers (2010) find that the quality of care for pneumonia mortality (0.3% and 3.14%) and stroke mortality (2.42% and 4.94%) both deteriorate at both HPH and EH after the merger. They conclude that hospital mergers do not improve quality of care.

Mutter et al. (2011) identify 42 hospital consolidations involving 136 hospitals in 16 states between 1999 and 2000 from the journal Modern Healthcare. They apply DID models to analyze the effects of hospital consolidation on inpatient quality of care using 25 quality indicators. Mutter et al. (2011) find that the effects of hospital consolidation on inpatient quality of care are minimal and vary across different quality measures and among the roles of the hospitals in a merger. For instance, Mutter et al. (2011) report that acquiring hospitals have significantly lower rates of iatrogenic pneumothorax than target hospitals after consolidation, and target hospitals' rates of obstetric trauma for vaginal deliveries with instrumentation increase significantly, while those of the hospitals that are in "mergers of equals" decrease (P.121). Mutter et al. (2011) suggest that hospitals' roles and the quality measures hospitals apply lead to different results of quality effects associated with mergers. However, Mutter et al. (2011) conclude that while evidence depicts that acquiring hospitals may increase slightly in certain quality measures, consolidations in general do not have a consistent impact on quality of care.

In addition, studies have indicated that high volume of health services provided by hospitals is associated with better patient outcomes (Halm et al., 2002; Livingston and Cao, 2010). A review done by Halm et al. (2002) demonstrates that high hospital and physician volume is in general related to better patient outcomes for various procedures and conditions. Using the MEDLINE database, Halm et al. (2002) identify 135 studies published between 1980 and 2000 that examine the association between hospital and physician volume with patient outcomes. Among the 135 studies examined, 107 studies use inpatient mortality rate as the primary patient outcome while the remaining studies use other outcomes such as stroke or other neurologic outcomes (Halm et al., 2002). Halm et al. (2002) apply chi-square tests to examine the association between positive results and methodologic characteristics. Halm et al. (2002) conclude that while hospital and physician volume is significantly associated with patient outcomes, the magnitude and consistency of such association differ significantly. Moreover, they find that such association is mostly significant and consistent for procedures and conditions such as pancreatic cancer, esophageal cancer, pediatric cardiac problems and the treatment of AIDS (Halm et al., 2002).

Literature review on association of hospital ownership, level, location and quality of care

Eggleston et al. (2008) perform a systematic review and meta-analysis on 31 empirical studies which examine the association of hospital ownership and quality of care. These 31 hospitals include at least two of the three ownership forms: government-owned, private not-for-profit and private for-profit. Of the 31 studies included in the meta-analysis, 25 use mortality rates while 13 apply other adverse patient outcomes. The sample years of these 31 studies range from 1984 to 2001.

Eggleston et al. (2008) find that studies that are representative of the entire US demonstrate that government-owned hospitals are significantly associated with higher mortality and adverse events rates than private not-for-private hospitals. However, Eggleston et al. (2008) indicate that such an association is systematically different in accordance with a study's data source, study period, and region studied. They find that studies which use state administrative databases from 1990 or later, hospital samples from a single state or modelling that excludes market competition show no difference in patient outcomes. Thus for further research, Eggleston et al. (2008) recommend an in-depth research on organizational decision-making and market-level changes of various economies to better analyze the association of hospital ownership and quality of care.

Hsieh and Cheng (2011) examine hospital location, hospital level and quality for acute coronary syndrome (ACS) patients using performance indicators for ACS. Hsieh and Cheng use patient data consisting of 2,388 ACS patients treated at 14 participating hospitals located in the northern, central and southern Taiwan between 2006 and 2007. Quality is measured by 12 quality indicators for ACS. Hsieh and Cheng (2011) find that southern Taiwan hospitals are significantly associated with better quality in terms of higher utilization rate of therapies recommended by the guidelines than the hospitals in northern and central Taiwan. However, Hsieh and Cheng (2011) indicate that hospitals in central Taiwan are generally associated with the worst quality mostly. In addition, Hsieh and Cheng (2011) also examine the association between hospital type and quality. They find that medical centers are associated with better quality than regional hospitals.

Another study done by Lin et al. (2003) also examines the association between hospital characteristics and quality of care. Lin et al. (2003) use patient level data consisting of 5,456 patients with vaginal delivery from the NHI Research Database in 1999 and maternity length of stay as a quality measure. Lin et al. (2003) find that length of stay is significantly associated with hospital level, hospital ownership, hospital location, and teaching status. Moreover, Lin et al. (2003) indicate that medical centers or regional hospitals are significantly associated with a higher length of stay than district hospitals. Also, public hospitals are significantly associated with longer lengths of stay than private hospitals. Furthermore, patients who give birth in northern Taiwan hospitals have significantly longer stays than those stay in central or southern Taiwan hospitals. For future research, Lin et al. (2003) suggest further investigation on the potential effects of the reduction in length of stay on the health condition of infants.

In contrast to Lin et al. (2003), a study done by Chang (2011) only uses public hospital which located in Taipei to examine the factors associated with quality. Chang (2011) examines what factors have impact on quality of care before and after the implementation of the National Health Insurance program, using fixed effect model and data of a total of 153 public hospitals located in Taipei for the period between 1989 and 2002. Chang (2011) uses morality rates and infection rates as dependent variables. The study’s independent variables include market factors (i.e. population aged 65 and above, market share, household income, total number of family, size of family, education, and family medical expenses), operational factors (i.e. beds, occupancy rates, average length of stay, new technology, doctors’ density, nurses to beds, and total operational costs/total sales), and financial factors (debt structure, and subsidy/sales). Chang (2011) finds that quality of care after the implementation of NHI has not improved and population over 65, competition, new technology, length of stay, the number of beds, doctors' density and nurses' density are associated with quality of care. Moreover, Chang (2011) concludes that lower doctors and nurses' density, longer length of stay, and increased aging population cause the quality of care to deteriorate. For future research, Chang (2011) suggests to examine the association further by using more quality indicators and larger sample size which includes private hospitals.

Methods

Data

The data on hospital quality of care is mainly from the website of the Ministry of Health and Welfare which provides a total of forty quality indicators including outcome and process of care measures. However, not all measures are applicable to all of the hospitals in Taiwan as some of the indicators measure the quality of care for specific conditions or illnesses such as the survival rates after organ implants, usage rate for certain drugs such as Aldosterone antagonist, or the rate of psychiatric patients returning to hospitals within 30 days of discharge. Furthermore, some hospitals may not provide the care or services measured by some indicators, thus not all hospitals are included in some measures. Moreover, because many of the quality indicators contain incomplete yearly information (eg. only Q3 to Q4 or Q 2 to Q4 for some years or a particular year), this study only uses the indicators that have complete yearly information. Seven of the quality measures which are related to the services that are common in the majority of hospitals in Taiwan are used for this study. These quality measures include mainly process measures:

1. The emergency department visit rate for Acute Myocardial Infarction (AMI) patients who returned to the hospital within 3 days after discharge (AMI)
2. The rate for outpatients revisiting the same hospital the same day after being treated for the same disease (Revisit)
3. The percentage of patients admitted to acute beds for more than 30 days (Acute)
4. The percentage of patients staying in the emergency room for more than 48 hours before being admitted (ER48)
5. The percentage of use of antibiotics for over 3 days after debridement (Antibio3)
6. The rate of emergency department visits for patients who return to the hospital within 3 days of discharge (ER3)
7. The percentage of patients being treated in the emergency room returning to the emergency room the same day after being treated. (ER1)

Based on the availability of the data compiled by the Ministry of Health and Welfare (MOHW) and the literature, the study includes hospital variables such as merged/non-merged hospitals, ownership (i.e. public/private), hospital level based on their accreditation (i.e. medical center, regional hospital, or district hospital), hospital location, acute bed number, and the number of hospitals in the same marketplace. In addition, for measuring the intensity of competition such as HHI, data on hospital discharges is unavailable for all hospitals and thus the study only applies the number of hospitals in the marketplace to measure density of competition. The data covers a period of four years (2011-2014) and contains a total number of 106 hospitals that are located in northern, central, and southern Taiwan. The northern region includes Taipei City, New Taipei City, Keelung City, and Yilan City. The central region includes Taichung City, Changhwa City, and Nantou City. The southern region includes Kaohsiung City and Pingtung City. These locations are chosen because they have Taiwan's highest populous cities - New Taipei City, Kaohsiung City, Taichung City and Taipei City (World Population Review, 2016). Moreover, of the 106 hospitals, there are 15 medical centers, 43, regional hospitals, and 48 district hospitals. From this group, there are 35 public and 71 private hospitals; 42 are located in northern Taiwan, 40 in southern Taiwan, and 24 in central Taiwan.

Table 4.1 shows the descriptive statistics of hospitals based on levels, and 4.2 shows the hospitals according to their ownership. Figure 4.1 shows the locations of the cities.

Statistical analysis

Statistical analysis is performed using SPSS version 23.0 (SPSS INC., Chicago, IL, USA). Generalized Linear Mixed Model (GLMM) is used in this study as the continuous outcomes are non-normally distributed. GLMM is an extension of generalized linear model, as indicated by the term 'linear' (Garson, 2013). As the term 'generalized' suggests, GLMM can handle outcomes of different types with various distributional assumptions such as normal or binomial or Poisson (McCulloch and Neuhaus, 2015). Moreover, as the term 'mixed' illustrates, GLMM includes both fixed and random predictors and relates the outcome to the linear predictors via a specified link function which describes how the dependent variable relates to the linear predictors (Kachman, 2016, MathWorks, 2016). In this study, GLMM is applied with an identity-link function which can be used for any distribution to model the mean directly (IBM SPSS, 2013). As the data on the quality measures is skewed, the natural logarithm is taken to transform the data in order to normalize the distributions before the analysis. Moreover, 0.01 adds to the zero values so that they would not be excluded in the analysis.

The unstructured covariance type is used as it makes no assumptions about the variances and covariances (Fitzmaurice et al., 2011) and often provides the best fit (Shek and Ma, 2011). Moreover, both the Akaike Information Criterion depicts the smallest values for the unstructured covariance type, suggesting that it is the preferable model. Moreover, the Bonferroni's method is used for multiple comparisons. It is used to avoid the chances of obtaining false-positive results (type I errors) when performing multiple pair wise tests on the same data set (Napierala, 2016). Furthermore, significance of association is defined as $P < 0.05$.

Four subgroups are created and analyzed separately. These four subgroups are: public vs private hospitals, hospitals located in the three different locations (north, central and south), hospitals categorized by the three different levels (medical center, regional, and district hospitals) and merged vs non-merged hospitals. Several factors are also included for the subgroup analyses such as the number of hospitals in the same district, number of acute beds, occupancy rate for acute beds, hospital ownership, hospital level, merger, and hospital location.

Results

Table 4.1 provides a summary of the hospitals' characteristics such as the number of acute beds, the annual averaged occupancy rate of the acute beds, and the seven quality indicators. Table 4.2 illustrates summary characteristics of hospitals based on hospital level, Table 4.3 is based on hospital ownership, Table 4.4 is based on merged/non-merged hospitals, and Table 4.5 is based on hospital location. Table 4.6 depicts the association between hospital factors and quality of care based on merger, hospital level, ownership, and location. The following table provides a summary of the findings on the association of hospital merger, ownership, level, location and quality in terms of the seven measures.

Summary table based the results illustrated in the following paragraphs:

Quality Indicator	Merger	Ownership	Level	Location
AMI		*P*-value < 0.05	*P*-value < 0.05	*P*-value < 0.05
Revisit			*P*-value < 0.05	*P*-value < 0.05
Acute		*P*-value < 0.05	*P*-value < 0.05	*P*-value < 0.05
ER48			*P*-value < 0.05	
ER3			*P*-value < 0.05	*P*-value < 0.05
ER1				*P*-value < 0.05
Antibio3				

Comparisons of hospitals in each factor:

Hospitals	Higher rates (lower quality)	Lower rates (better quality)	Overall quality
Merger			
Merged	ER48, ER1, Antibio3	AMI, Revisit, Acute, ER3	**Mixed**
Non-merged	AMI, Revisit, Acute, ER3	ER48, ER1, Antibio3	**Mixed**
Ownership			
Private		AMI, Revisit	**Good**
Public	AMI, Revisit, Acute, ER48, ER3, ER1, Antibio3		**Bad**

Level	**Highest rates (Worst quality)**	**Medium**	**Lowest rates (Best quality)**	**Overall quality**
Medical CTR	Revisit, Acute, ER48, ER3, ER1	AMI	Antibio3	**Worst**
Regional	AMI, Antibio3	Revisit, Acute, ER48, ER3	ER1	
District		ER1, Antibio3	AMI, Revisit, Acute, ER48, ER3	**Best**
Location				
Northern	Acute, ER48, ER3, Antibio3	AMI, Revisit, ER1		**Worst**
Central	AMI, Revisit, ER1		Acute, ER48, ER3, Antibio3	
Southern		Acute, ER48, ER3, Antibio3	AMI, Revisit, ER1	**Best**

Merger

As depicted in Table 4.6 and the above tables, the results show mixed (i.e. both positive and negative effects) results. Merger is insignificantly associated with all quality measures ($P > 0.05$). However, the multiple comparison shows that merged hospitals depict insignificant lower rates (better quality) in terms of measures such as AMI, Revisit, Acute, and ER3, while non-merged hospitals have insignificant lower rates (better quality) in terms of measures such as ER48, ER1, and Antibio3. Although these results may suggest that hospital mergers affect quality of care in different areas (Mutter et al., 2008), they do depict that hospital merger does not have an overall positive impact on quality of care. Furthermore, while empirical findings provide mixed evidence, the majority of studies demonstrate that hospitals mergers reduce quality of care (Williams et al., 2006).

Ownership

The above tables show that hospital ownership is significantly associated with quality in terms of AMI and Acute. However, for all measures, public hospital ownership is associated with higher rates (poorer quality) than private hospital ownership. This may suggest that public hospitals in the dataset are less efficient in providing process care than private hospitals. This result is consistent with literature that public hospitals have poorer quality of care than private hospitals. To improve the quality of public hospitals, one solution may be to privatize these hospitals. This will be discussed in greater details in the discussion section.

Hospital level

As Table 4.6 and the above tables illustrate, all three hospital levels are significantly associated with quality indicators in terms of AMI, Revisit, Acute, ER3, and ER48. Besides AMI, medical centers significantly show the highest rates, followed by the regional and district hospitals. However, this may be because medical centers in general receive patients with more severe and complex conditions than hospitals, and thus result in higher quality measures. Alternatively, it may be due to the overcrowding problem in large hospitals (see Discussion section). For the AMI rate, regional hospitals have the highest rate, followed by medical centers, and district hospitals. This result is consistent with prior research that also finds regional hospitals have higher inpatient AMI mortality rate than medical centers (Liu et al., 2014). However, the researchers indicate that the reason that regional hospitals have higher AMI mortality rate may not be mainly due to the differences in hospital levels but the cardiologist service volume and percutaneous coronary intervention performed in the hospitals (Ibid). Thus such association can be further investigated when more detailed hospital data such as the cardiologist service volume and the number of percutaneous coronary intervention performed is made available. In general, medical centers and regional hospitals are significantly associated with higher rates (poorer quality) than district hospitals.

Location

Table 4.6 and the above tables depict that there is significant association between hospital locations and quality in terms of AMI, Revisit, Acute, ER3, and ER1. Among these measures, hospitals in the southern region are significantly associated with the highest quality (lowest rates) on AMI, Revisit, Acute, and ER1. While hospitals in central region are significantly associated with the worst quality (highest rates) for AMI, Revisit, and ER1, and hospitals in northern region are associated with significantly worst quality (highest rates) on Acute and ER3. Moreover, hospitals in central region are significantly associated with the highest quality (lowest rates) in ER3. In generally, hospitals in the southern locations are significantly associated with better quality than the other two locations.

Subgroup Analysis: association of competition, acute bed size and quality

Research depicts that hospital size and competition affect quality of care (Brownlee and Saini, 2014; Whiet et al., 2014; Dash and Meredith, 2010). Empirical evidence indicates that bigger hospitals have higher prices but they do not necessarily offer better quality of care (Brownlee and Saini, 2014; Whiet et al., 2014). However, empirical evidence does not provide consistent findings on the association of hospital competition and quality. The reason that hospital competition does not improve quality of care may be due to information symmetry between providers and patients, moral hazard, adverse selection (Dash and Meredith, 2010). Therefore, this study also examines the association between hospital size, competition and quality of care in the subgroup analysis. The following table briefly summarizes the results from the subgroup analysis on the association of hospital size, competition and quality of care.

Results from the subgroup analysis:

Hospital +beds	AMI	Revisit	Acute	ER48	ER3	ER1	Antibio3	+Competition
Merged								x
Non-M		+	+	+	+			x
Private	+	+	+	+	+			x
Public		+	+	+				-ER1
Med Ctr			+				+	x
Regional			+					x
District		+	+	+				x
Northern		+	+	+				x
Southern		+	+	+	+			x
Central		+		+	+			x

+ = significantly positive; x = insignificant

Private/Public hospitals

Table 4.7 to Table 4.13 and the above table show the results on the relationships between competition, the number of acute beds and quality for public and private hospital ownerships. There is a significantly positive association between the number of acute beds and quality on all measures except Antibio3 and ER1 for private hospital ownership. However, for public hospital ownership, the number of acute beds is only significantly and positively associated with quality in terms of Acute, Revisit, and ER48. In general, both private and public hospital ownerships with a larger number of acute beds have poorer quality than those with a small number of acute beds.

Moreover, there is a mixed (both negative and positive) association between competition and quality on all measures for both public and private hospital ownerships. Besides ER1, all results on the association of competition and quality for both ownerships are insignificant. For public hospital ownership, there is a negative and significant association between the number of competitors and quality in terms of ER1. This suggests that when there is more competition, public hospitals have better quality in terms of reducing the number of patients returning to ER on the same day after discharging from the same ER than private hospital ownership. However, in terms of quality for all measures, private hospitals are not likely to be affected by the density of competition in the marketplace.

Merged/non-merged

Table 4.14 to Table 4.20 and the above table show the results on the association between competition, the number of acute beds and quality for merged and non-merged hospitals. The results indicate that non-merged hospitals are associated with a significantly positive association between the number of acute beds and quality on the four process measures: Acute, Revisit, ER3, and ER48. This suggests that non-merged hospitals with a higher number of the acute beds are associated with significantly lower quality on these measures. However, for merged hospitals, the association between the number of acute beds and quality is insignificant. In general, for both merged and non-merged hospitals, the association between competition and quality is insignificant and mixed which includes both positive and negative effects. This suggests that the effect of competition on the quality of both merged and non-merged hospitals is mixed.

Medical centers/regional hospitals/district hospitals

Table 4.21 to Table 4.27 and the above table illustrate the results on the relationships between competition, the number of acute beds and quality for medical centers, regional hospitals, and district hospitals. In the area of Acute for all levels of hospitals, there is a significantly positive association between the number of acute beds and quality. This suggests that the higher number of acute beds there are, then the poorer the quality in treating patients with acute diseases regardless of whether the hospital is a medical center, regional, or district hospital. Moreover, only district hospitals have a significant and positive association between the number of acute beds and quality in terms of Revisit and ER48. Only medical centers show significantly positive associations between the number of acute beds and quality in terms of Antibio3. Furthermore, there is an insignificant association between the number of acute beds and quality in terms of measures besides Acute for the regional hospitals. With regards to competition, there is insignificant and mixed (both positive and negative) association between competition and quality for all types of hospitals.

Northern/Southern/Central Taiwan hospitals

Table 4.28 to Table 4.34 and the above table illustrate the results on the relationships between competition, the number of acute beds and quality for hospitals located in the three different locations: northern, central, and southern Taiwan. There is a significant and positive association between the number of acute beds and quality only in terms of Revisit and ER 48 (crowding in emergency rooms) for all locations. This suggests that hospitals in all locations with a higher number of acute beds are significantly associated with higher rates of Revisit. Moreover, hospitals in both northern and southern Taiwan with more acute beds are significantly associated with higher rates of Acute. For quality in terms of ER3, the association is significant and positive for both hospitals in the southern and central regions. For other measures, the association between the number of acute beds and quality is also positive yet insignificant. Furthermore, hospitals in all the locations have insignificant and mixed associations between competition and quality on all measures.

Discussion

In this study, the association between hospitals and quality based on merged/non-merged, ownership, location, and level is examined. Also, subgroup analyses on the relationship between competition, the number of acute beds and quality are conducted. The results show that a hospital's quality may be affected differently by the hospital's ownership, merger, level, and location. In general, results found in this study are consistent with the findings of existing literature examining the healthcare industry in Taiwan. For example, the results in this study demonstrate that hospitals with more acute beds such are associated with higher rates (poorer quality) in most quality measures. This result is consistent with existing findings (Lin et al., 2003). Moreover, the poorer quality found in medical centers and regional hospitals could be due to the overcrowding of patients with minor conditions in medical centers and regional hospitals (Cheng, Y.W., 2015). As patients have easy access and freedom of choice to seek care in Taiwan (Cheng, T.M., 2015), they are used to seeking care in medical centers and regional hospitals even when they only have minor illnesses (Wang and Cheng, 2005). Consequently, such situations obstruct medical centers or regional hospitals from providing timely and adequate care to patients with more complex and acute illnesses (Wang and Cheng, 2005). Moreover, the higher rates observed in both medical centers and regional hospitals may partly be due to the fact that they are more likely to receive a higher proportion of patients with more complex and acute illnesses than district hospitals (Lin et al., 2003).

All levels of hospitals are significantly associated with quality of care in terms of Revisit, ER48, and Acute. This result is consistent with the report called the 2014 Population Healthcare Quality Indicator Report done by MOHW. In this report, the performance of hospitals in Taiwan is compared to that of OECD countries. Taiwan is rated with the worst grades (D) in these areas (Cheng, 2015): Doctors spend enough time with patients on visits; and Doctors' communication with patients is easily understandable. This suggests that the reason that all hospitals are significantly associated with quality on Revisit could be because of the insufficient time spent on each visit to achieve effective communication between patients and doctors. Thus patients return to the same hospitals on the same day for treatment with the same illness after visiting. Moreover, the result on the significant association with ER48 for all hospitals is consistent with literature and such emergency room overcrowding problem may result from the low costs of ED visits and the aging populations since older patients tend to have more urgent visits and longer stays in the ER (Yang et al., 2009). Furthermore, the high Acute rates may result from the inappropriate or unnecessary use of inpatient services as research examining the appropriateness of hospital stay longer than 30 days in acute care hospitals finds that a significant percentage of hospital bed days has been used for patients without further medical needs (Chiu et al., 2003). The researchers conclude that larger hospitals have higher percentages of such inappropriate-stay patients and this may be due to hospital factors, patient characteristics, and the payment schemes of NHI (Ibid).

The effect of competition on quality depicts mixed and insignificant results. Both merged and non-merged hospitals have insignificant and mixed (both positive and negative) association with quality of care. However, the results are consistent with the findings of existing literature that demonstrates mixed results on the association between hospital competition and quality of care (Bijlsma et al., 2010; Mutter et al., 2008; Propper et al., 2008; Palangkaraya and Yong, 2013). Similarly, the association between merged, non-merged hospitals and quality also shows mixed results which are consistent with those of various studies that examine the effect of hospital merger on quality ((Capps, 2005; Cuellar and Gertler, 2003; Mutter et al., 2011; Romano and Balan, 2010).

For all measures, public hospital ownership is associated with poorer quality than private hospital ownership. This finding is consistent with the findings of existing literature (Chang et al., 2004; Eggleston et al., 2008). For Taiwan, the findings observed in this study may have resulted from public hospitals' lack of supportive supervision and continued reduction of subsidies from the government (Cheng, 2011). On the contrary, private hospitals are mostly owned by large business conglomerates with sufficient funding for investment in medical technology, expansion in operating facilities (Ibid). Since usage of advanced technology is associated with better quality of care (Chang, 2011), private hospitals are thus more likely to sustain a good quality of care. Moreover, policy makers may privatize the public hospitals to improve the quality of public hospitals, as research demonstrates that private hospitals improve quality management and hospital outcomes (Busse et al., 2009). Indeed, researchers examining the outcomes of privatization of public hospitals find evidence that privatization leads to efficiency gains and better quality (Tiemann and Schreyogg, 2012).

The study includes hospital locations in northern, central and southern Taiwan to examine whether quality differs geographically. The study finds that southern Taiwan hospitals are significantly associated with higher quality of care compared to hospitals in the central and northern Taiwan. Although, using different quality indicators, this study finds results consistent to existing literature (Hsieh and Chen, 2011). The reason that southern Taiwan's hospitals demonstrate better quality may contribute to their practice in accordance with guidelines and industry standards. However, as Hsieh and Cheng (2011) indicate, the association of geographical differences and quality of care needs to be investigated further. The inclusion of patient data, more detailed hospital level data, and other quality measures may help substantiate the findings.

This study has limitations. Due to the limited access to relevant hospital data, this study does not include information and data such as average length of stay, average occupancy, CMI, and annual discharges for all hospitals in every year for the period of statistical analysis. As such, this may influence the robustness of the study results. Also, the existing quality measures included in this study may not represent all quality aspects and the range of quality measures used in this study is relatively small. Therefore, further research that includes other outcomes measures could add greater validation to the study's robustness. Furthermore, in future research, this study can be expanded by including a larger sample of hospitals across all regions in Taiwan, more detailed hospital and patient level data, and outcome measures spanning a longer period of time. This would help substantiate the findings.

Conclusion

This is the first study to examine the relationships between hospital ownership, merged/non-merged, levels, and locations with quality in terms of process measures using the hospital level data. As there is limited current research on quality of care in the context of Taiwan, this study serves as a foundation for further research. Based on the findings of this study, there is still room for further improvement in terms of the overall quality of all hospitals. The study finds hospital ownerships, levels, and locations are associated with quality in terms of certain process measures. However, the study finds insignificant and mixed relationships between hospital competition, mergers and quality. Moreover, the study finds significant association between the number of acute beds and quality. Larger hospitals depict weaker quality in terms of certain measures shown in the results section. Furthermore, the evidence shows that public hospitals have poorer quality. While this study finds that ownership, level, and location are associated with quality, the important implications underlying such associations highlight the fundamental problems pertaining to each type of hospitals. These problems may have originated from public policies, management practices, and hospital culture. However, in view of the growing aging population and the increasing medical needs, policy attention to address the fundamental issues pertaining to these hospitals in order to improve their quality of care is crucial.

Table 4.1 Summary statistics of all hospitals, 2011-2014

Descriptive Statistics

	N*	Minimum	Maximum	Mean	Std. Deviation
NoCompetitorΦ	424	0	13	3.45	2.86
Acutebeds♠	424	27	3093	503.70	537.46
Acuteocuppy╬	314	14.58	93.87	64.53	16.56
AMI†	424	.00	100.00	8.53	16.40
Revisit◊	424	.01	2.64	.82	.49
Acute%	420	.00	4.82	1.34	.91
ER48¶	420	.00	28.01	2.26	4.97
ER3#	420	.00	5.96	1.80	1.22
ER1☼	420	.00	4.03	.47	.62
Antibio3‡	420	.00	100.00	20.86	19.90

Φ = The number of hospitals in the market

♠ = The number of acute beds in a hospital

╬ = The occupancy rate of acute beds in a hospital

† = Emergency department visit rate for Acute Myocardial Infarction (AMI) patients who returned to the hospital within 3 days after discharge

◊ = Rate for outpatients revisiting the same hospital the same day after being treated for the same disease

% = The percentage of patients staying in acute beds for more than 30 days

¶ = Percentage of patients staying in emergency room (ER) for more than 48 hours before being admitted

= Percentage of ER visits of patients who return to the hospital after 3 days of discharge

☼ = Percentage of patients returning to ER the same day after being treated in the ER

‡ = Percentage of patients receiving antibiotic treatment for more than 3 days after debridement

*N contains data for 4 years and thus each number needs to be divided by four. Odd numbers are due to missing numbers.

Table 4.2 Summary of quality indicators based on hospital levels

Type3!		N*	Minimum	Maximum	Mean	Std. Deviation
1.00	AMI†	60	.00	3.38	1.19	.94
	Revisit◊	60	.65	2.60	1.26	.48
	Acute%	60	.98	3.92	2.20	.74
	ER48¶	60	.02	28.01	9.51	7.54
	ER3#	60	1.08	5.62	2.25	.72
	ER1☼	60	.01	3.67	.50	.81
	Antibio3‡	60	1.28	24.29	7.72	4.71
	Acutebeds♠	60	618	2805	1355.72	613.03
	Acuteocuppy╬	45	54.52	89.90	79.43	9.39
	NoCompetitorΦ	60	0	13	3.87	3.23
	AMI	171	.00	42.86	4.55	6.33
2.00	Revisit	171	.25	2.64	.934	.44
	Acute	171	.09	4.82	1.38	.83
	ER48	171	.00	16.20	1.21	2.97
	ER3	171	.00	5.96	2.12	.96
	ER1	171	.00	2.28	.43	.34
	Antibio3	171	.00	64.48	20.15	15.20
	Acutebeds	171	183	3093	583.23	416.21
	Acuteocuppy	129	35.42	88.17	65.26	13.61
	NoCompetitor	171	0	10	3.53	3.02
	AMI	193	.00	100.00	14.33	22.18
	Revisit	193	.01	2.51	.59	.41
3.00	Acute	189	.00	4.59	1.02	.84
	ER48	189	.00	20.16	.92	3.09
	ER3	189	.00	5.62	1.37	1.40
	ER1	189	.00	4.03	.51	.73
	Antibio3	189	.00	100.00	25.67	24.25
	Acutebeds	193	27	1043	168.35	148.38
	Acuteocuppy	140	14.58	93.87	59.06	17.79
	NoCompetitor	193	0	10	3.25	2.50

!1 = medical centers; 2 = regional hospitals; 3 = district hospitals

*N contains data for 4 years and thus each number needs to be divided by four. Odd numbers are due to missing values.

† = Emergency department visit rate for Acute Myocardial Infarction (AMI) patients who returned to the hospital within 3 days after discharge

◊ = Rate for outpatients revisiting the same hospital the same day after being treated for the same disease;

% = The percentage of patients staying in acute beds for more than 30 days

‡ = Percentage of patients receiving antibiotic treatment for more than 3 days after debridement

¶ = Percentage of patients staying in emergency room (ER) for more than 48 hours before being admitted;

Φ = The number of hospitals in the market;

♠ = The number of acute beds in a hospital

╬ = The occupancy rate of acute beds in a hospital

= Percentage of ER visits of patients who return to the hospital after 3 days of discharge

☼ = Percentage of patients returning to ER the same day after being treated in the ER

Table 4.3 Summary of quality indicators based on hospital ownership

Descriptive Statistics

Hospital ownership		**N***	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
0	AMI†	284	.00	100.00	7.56	15.54
	Revisit◊	284	.01	2.64	.81	.51
	Acute%	280	.00	4.82	1.10	.83
	ER48¶	280	.00	23.03	1.89	4.22
	ER3#	280	.00	5.96	1.69	1.29
	ER1☼	280	.00	3.74	.48	.65
	Antibio3‡	280	.00	100.00	20.76	19.59
	Acutebeds♠	284	27	1833	422.62	404.94
	Acuteocuppy╬	209	14.58	93.87	64.21	16.97
	NoCompetitorΦ	284	0	13	3.51	2.90
1	AMI	140	.00	100.00	10.48	17.92
	Revisit	140	.20	2.60	.84	.45
	Acute	140	.07	4.59	1.80	.88
	ER48	140	.00	28.01	3.02	6.14
	ER3	140	.00	4.70	2.04	1.01
	ER1	140	.00	4.03	.46	.55
	Antibio3	140	.00	95.56	21.05	20.56
	Acutebeds	140	97	3093	668.16	710.31
	Acuteocuppy	105	30.90	89.10	65.15	15.77
	NoCompetitor	140	0	10	3.32	2.69

 0 = private hospitals; 1 = public hospitals
* = needs to be divided by 4 because the data contains a period of 4 years. Odd numbers are due to missing values.
Φ = The number of hospitals in the market
♠ = The number of acute beds in a hospital
╬ = The occupancy rate of acute beds in a hospital
† = Emergency department visit rate for Acute Myocardial Infarction (AMI) patients who returned to the hospital within 3 days after discharge
◊ = Rate for outpatients revisiting the same hospital the same day after being treated for the same disease
% = The percentage of patients staying in acute beds for more than 30 days
¶ = Percentage of patients staying in emergency room (ER) for more than 48 hours before being admitted
# = Percentage of ER visits of patients who return to the hospital after 3 days of discharge
‡ = Percentage of patients receiving antibiotic treatment for more than 3 days after debridement
☼ = Percentage of patients returning to ER the same day after being treated in the ER

Table 4.4 Summary quality indicators based on merged and non-merged hospitals

Hosp ♫		N*	Minimum	Maximum	Mean	Std. Deviation
.00	AMI†	412	.00	100.00	8.69	16.60
	Revisit◊	412	.01	2.64	.83	.50
	Acute%	408	.00	4.82	1.33	.91
	ER48¶	408	.00	28.01	2.32	5.03
	ER3#	408	.00	5.96	1.79	1.23
	ER1☼	408	.00	4.03	.47	.62
	Antibio3‡	408	.00	100.00	20.93	20.16
	Acutebeds♠	412	27	2805	482.90	488.95
	Acuteocuppy╬	305	14.58	93.87	64.81	16.61
	NoCompetitorΦ	412	0	13	3.47	2.86
1.00	AMI	12	.00	8.62	2.93	3.34
	Revisit	12	.41	1.52	.58	.29
	Acute	12	.43	2.73	1.52	.89
	ER48	12	.00	1.13	.34	.42
	ER3	12	1.50	2.97	2.13	.55
	ER1	12	.10	.88	.64	.27
	Antibio3	12	9.17	30.00	18.52	6.26
	Acutebeds	12	325	3093	1217.58	1266.22
	Acuteocuppy	9	37.95	65.40	54.82	11.49
	NoCompetitor	12	0	4	2.92	1.62

♫ .00 = non-merged hospitals; 1.00 = merged hospitals
* Number needs to be divided by 4 because the data contains a period of 4 years. Odd numbers are due to missing values
Φ = The number of hospitals in the market
♠ = The number of acute beds in a hospital
╬ = The occupancy rate of acute beds in a hospital
† = Emergency department visit rate for Acute Myocardial Infarction (AMI) patients who returned to the hospital within 3 days after discharge
◊ = Rate for outpatients revisiting the same hospital the same day after being treated for the same disease
% = The percentage of patients staying in acute beds for more than 30 days
¶ = Percentage of patients staying in emergency room (ER) for more than 48 hours before being admitted
# = Percentage of ER visits of patients who return to the hospital after 3 days of discharge
☼ = Percentage of patients returning to ER the same day after being treated in the ER
‡ = Percentage of patients receiving antibiotic treatment for more than 3 days after debridement

Table 4.5 Summary on quality indicators based on locations

area3&		N*	Minimum	Maximum	Mean	Std. Deviation
11.00	AMI†	168	.00	100.00	9.2	17.24
	Revisit◊	168	.09	2.60	.84	.43
	Acute%	168	.00	4.82	1.62	.90
	ER48¶	168	.00	28.01	3.10	5.94
	ER3#	168	.00	5.10	2.36	.99
	ER1☼	168	.00	4.03	.39	.53
	Antibio3‡	168	.00	100.00	20.06	17.69
	Acutebeds♠	168	82	3093	602.87	668.78
	Cardiolo§	165	1	41	11.03	10.15
	Acuteocuppy╬	126	23.56	88.60	64.93	17.82
	NoCompetitorΦ	168	0	7	2.74	2.11
22.00	AMI	160	.00	100.00	6.45	15.23
	Revisit	160	.01	2.51	.75	.53
	Acute	156	.00	3.67	1.24	.97
	ER48	156	.00	23.03	2.53	4.99
	ER3	156	.00	5.62	1.64	1.04
	ER1	156	.00	1.29	.29	.27
	Antibio3	156	.00	90.95	22.68	22.02
	Acutebeds	160	27	1833	457.42	474.70
	Acuteocuppy	116	14.58	93.87	66.43	15.97
	NoCompetitor	160	0	13	4.41	3.18
33.00	AMI	96	.00	66.67	10.79	16.54
	Revisit	96	.04	2.64	.90	.50
	Acute	96	.04	3.27	1.00	.64
	ER48	96	.00	5.96	.38	1.10
	ER3	96	.00	5.96	1.09	1.39
	ER1	96	.00	3.74	.92	.90
	Antibio3	96	.00	75.59	19.30	19.90
	Acutebeds	96	61	1308	407.27	304.01
	Acuteocuppy	72	35.42	90.42	60.75	14.69
	NoCompetitor	96	0	10	3.10	2.89

& 11 = hospitals located in the Northern region; 22 = hospitals in Southern region; 33 = hospitals in Central Taiwan

* Number needs to be divided by 4 because the data contains a period of 4 years. Odd numbers are due to missing values

Φ = The number of hospitals in the market

♠ = The number of acute beds in a hospital

╬ = The occupancy rate of acute beds in a hospital

† = Emergency department visit rate for Acute Myocardial Infarction (AMI) patients who returned to the hospital within 3 days after discharge

◊ = Rate for outpatients revisiting the same hospital the same day after being treated for the same disease

% = The percentage of patients staying in acute beds for more than 30 days

¶ = Percentage of patients staying in emergency room (ER) for more than 48 hours before being admitted

= Percentage of ER visits of patients who return to the hospital after 3 days of discharge

☼ = Percentage of patients returning to ER the same day after being treated in the ER

‡ = Percentage of patients receiving antibiotic treatment for more than 3 days after debridement

Table 4.6 Association between hospitals and quality of care: based on levels, ownership, merged/non-merged, or locations

Quality Indicator	Hospital variable§	F Statistics	P Value	Post Hoc Analysis
AMI†	Type 3	3.625	0.027	Regional > Medical CTR
	Public	5.922	0.015	Public > Private
	Hosp2	2.715	0.100	
	Area 3	4.095	0.017	Central > Northern region
Revisit◊	Type 3	12.928	0.000	Medical CTR > Regional
	Public	0.021	0.885	
	Hosp2	1.504	0.221	
	Area 3	4.095	0.017	Central > Northern
Acute%	Type3	8.092	0.000	Medical CTR > Regional
	Public	11.270	0.001	Public > Private
	Hosp2	0.139	0.709	
	Area3	4.807	0.009	Northern > Central
ER48¶	Type3	38.892	0.000	Medical CTR > Regional
	Public	0.284	0.595	
	Hosp2	0.007	0.934	
	Area 3	2.417	0.090	
ER3#	Type 3	7.898	0.000	Medical CTR >Regional
	Public	0.133	0.715	
	Hosp2	0.060	0.807	
	Area 3	25.831	0.000	Northern > Southern
ER1☼	Type 3	0.067	0.936	
	Public	1.706	0.192	
	Hosp2	1.260	0.262	
	Area 3	11.921	0.000	Central > Northern
Antibio3‡	Type 3	1.200	0.302	
	Public	0.058	0.810	
	Hosp2	0.024	0.876	
	Area 3	0.427	0.653	

† = Emergency department visit rate for Acute Myocardial Infarction (AMI) patients who returned to the hospital within 3 days after discharge
◊ = Rate for outpatients revisiting the same hospital the same day after being treated for the same disease
% = The percentage of patients staying in acute beds for more than 30 days
¶ = Percentage of patients staying in emergency room (ER) for more than 48 hours before being admitted
# = Percentage of ER visits of patients who return to the hospital after 3 days of discharge
☼ = Percentage of patients returning to ER the same day after being treated in the ER
‡ = Percentage of patients receiving antibiotic treatment for more than 3 days after debridement

§ Type 3 = medical Center, regional hospitals, district hospitals; Public = public vs. private hospitals; Hosp2 = merged vs. non-merged hospitals; Area 3 = Northern, Central, and Southern locations

Table 4.7 ~ Table 4.13 Association between acute bed size, number of hospitals in the same area and quality for public (1) and private (0) hospitals

Emergency department visit rate for Acute Myocardial Infarction (AMI) patients who returned to the hospital within 3 days after discharge

Public	Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
0	Intercept	-1.402243	.439983	91.561	-3.187	.002	-2.276144	-.528343
	NoCompetitor	-.099090	.081986	92.645	-1.209	.230	-.261906	.063727
	Acutebeds	.001653	.000591	90.471	2.799	.006	.000480	.002827
1	Intercept	-.169848	.645970	40.568	-.263	.794	-1.474833	1.135136
	NoCompetitor	.076807	.126260	40.491	.608	.546	-.178278	.331892
	Acutebeds	-.000148	.000478	40.283	-.309	.759	-.001114	.000819

Rate for outpatients revisiting the same hospital the same day after being treated for the same disease

Public	Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
0	Intercept	-.785098	.123225	79.913	-6.371	.000	-1.030327	-.539869
	Acutebeds	.001001	.000167	79.147	5.993	.000	.000668	.001333
	NoCompetitor	-.020141	.021923	97.619	-.919	.361	-.063647	.023366
1	Intercept	-.333161	.124896	42.397	-2.668	.011	-.585142	-.081180
	Acutebeds	.000261	9.56129 4E-5	37.151	2.729	.010	6.725104E-5	.000455
	NoCompetitor	-.029075	.023598	50.720	-1.232	.224	-.076456	.018306

The percentage of patients staying in acute beds for more than 30 days

Public	Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
0	Intercept	-.986815	.196275	73.300	-5.028	.000	-1.377963	-.595667
	Acutebeds	.001427	.000265	72.296	5.374	.000	.000898	.001956
	NoCompetitor	.007432	.036180	77.243	.205	.838	-.064609	.079472
1	Intercept	.148615	.155129	41.877	.958	.344	-.164474	.461705
	Acutebeds	.000394	.000116	39.633	3.394	.002	.000159	.000629
	NoCompetitor	-.001949	.030072	44.284	-.065	.949	-.062545	.058646

Percentage of patients staying in emergency room (ER) for more than 48 hours before being admitted

Public	Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
0	Intercept	-3.774927	.350781	81.604	-10.762	.000	-4.472792	-3.077062
	Acutebeds	.003802	.000474	80.529	8.014	.000	.002858	.004746
	NoCompetitor	-.038069	.064670	85.759	-.589	.558	-.166635	.090497
1	Intercept	-2.577375	.636074	41.138	-4.052	.000	-3.861822	-1.292928
	Acutebeds	.001971	.000481	37.392	4.094	.000	.000996	.002946
	NoCompetitor	-.088462	.121860	46.129	-.726	.472	-.333735	.156812

Percentage of ER visits of patients who return to the hospital after 3 days of discharge

							95% Confidence Interval	
	Parameter	Estimate	Std. Error	df	t	Sig.	Lower Bound	Upper Bound
0	Intercept	-.843337	.334913	78.789	-2.518	.014	-1.509993	-.176682
	Acutebeds	.001547	.000454	77.958	3.406	.001	.000643	.002452
	NoCompetitor	-.014543	.060604	89.292	-.240	.811	-.134956	.105869
1	Intercept	-.426902	.420178	47.425	-1.016	.315	-1.271990	.418187
	Acutebeds	.000349	.000329	39.399	1.062	.295	-.000316	.001014
	NoCompetitor	.136729	.076871	65.061	1.779	.080	-.016791	.290249

Percentage of patients returning to ER the same day after being treated in the ER

							95% Confidence Interval	
Public	Parameter	Estimate	Std. Error	df	t	Sig.	Lower Bound	Upper Bound
0	Intercept	-1.502234	.262481	78.541	-5.723	.000	-2.024738	-.979731
	Acutebeds	.000510	.000356	77.731	1.432	.156	-.000199	.001219
	NoCompetitor	-.043596	.047442	89.443	-.919	.361	-.137856	.050663
1	Intercept	-.602217	.257894	40.526	-2.335	.025	-1.123230	-.081205
	Acutebeds	-.000370	.000192	39.089	-1.925	.061	-.000759	1.868546E-5
	NoCompetitor	-.111176	.050225	41.813	-2.214	.032	-.212549	-.009804

Percentage of patients receiving antibiotic treatment for more than 3 days after debridement

Public	Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
0	Intercept	2.366951	.352088	77.997	6.723	.000	1.665998	3.067904
	Acutebeds	.000368	.000475	76.938	.774	.441	-.000579	.001314
	NoCompetit	-.117777	.065263	80.273	-1.805	.075	-.247648	.012093
1	Intercept	1.862885	.528825	36.779	3.523	.001	.791168	2.934603
	Acutebeds	.000295	.000394	35.294	.748	.459	-.000505	.001095
	NoCompetit	.052597	.102909	38.174	.511	.612	-.155699	.260893

Table 4.14 to Table 4.20

Association between acute bed size, number of hospitals in the same area and quality for merged (1) and non-merged (0) hospitals

Emergency department visit rate for Acute Myocardial Infarction (AMI) patients who returned to the hospital within 3 days after discharge

Hosp2	Parameter	Estimate	Std. Error	df	T	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
.00	Intercept	-.868222	.378303	131.119	-2.295	.023	-1.616590	-.119855
	NoCompetitor	-.032637	.071880	132.067	-.454	.651	-.174821	.109547
	Acutebeds	.000604	.000422	129.729	1.432	.154	-.000230	.001439
1.00	Intercept	-.833114	9.296174	8.421	-.090	.931	-22.084827	20.418599
	NoCompetitor	-.664516	2.084083	8.456	-.319	.758	-5.425651	4.096620
	Acutebeds	.001098	.002647	8.098	.415	.689	-.004994	.007190

Rate for outpatients revisiting the same hospital the same day after being treated for the same disease

Hosp2	Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
.00	Intercept	-.640030	.094205	118.007	-6.794	.000	-.826581	-.453479
	Acutebeds	.000734	.000107	111.372	6.855	.000	.000522	.000947
	NoCompetitor	-.024911	.017075	146.680	-1.459	.147	-.058655	.008833
1.00	Intercept	-.097748	1.219564	11.919	-.080	.937	-2.756949	2.561453
	Acutebeds	-.000147	.000346	11.658	-.426	.678	-.000903	.000609
	NoCompetitor	-.108342	.273549	11.938	-.396	.699	-.704697	.488013

The percentage of patients staying in acute beds for more than 30 days

Hosp2	Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
.00	Intercept	-.621900	.156968	108.057	-3.962	.000	-.933035	-.310764
	Acutebeds	.001023	.000177	105.317	5.794	.000	.000673	.001373
	NoCompetitor	.005219	.029513	114.605	.177	.860	-.053243	.063681
1.00	Intercept	-.626451	1.671898	11.361	-.375	.715	-4.292047	3.039146
	Acutebeds	.000520	.000488	11.888	1.064	.309	-.000546	.001585
	NoCompetitor	.063764	.373581	11.258	.171	.868	-.756188	.883717

Percentage of patients staying in emergency room (ER) for more than 48 hours before being admitted

Hosp2	Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
.00	Intercept	-3.389212	.314016	115.839	-10.793	.000	-4.011170	-2.767254
	Acutebeds	.003203	.000353	112.850	9.066	.000	.002503	.003903
	NoCompetitor	-.059784	.058981	123.228	-1.014	.313	-.176531	.056963
1.00	Intercept	-1.963176	3.581190	11.183	-.548	.594	-9.829655	5.903302
	Acutebeds	.000701	.001042	11.878	.673	.514	-.001572	.002973
	NoCompetitor	-.346516	.800699	11.049	-.433	.674	-2.107883	1.414851

Percentage of ER visits of patients who return to the hospital after 3 days of discharge

Hosp2	Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
.00	Intercept	-.663132	.278060	115.578	-2.385	.019	-1.213886	-.112379
	Acutebeds	.000933	.000315	110.436	2.959	.004	.000308	.001558
	NoCompetitor	.034823	.051102	135.119	.681	.497	-.066239	.135885
1.00	Intercept	.434998	.449661	11.966	.967	.352	-.545043	1.415038
	Acutebeds	.000201	.000129	11.988	1.564	.144	-7.906944 E-5	.000482
	NoCompetitor	.018115	.100754	11.951	.180	.860	-.201510	.237740

Percentage of patients returning to ER the same day after being treated in the ER

Hosp2	Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
.00	Intercept	-1.152634	.202025	114.412	-5.705	.000	-1.552828	-.752439
	Acutebeds	-5.814223E-5	.000228	110.449	-.255	.799	-.000510	.000394
	NoCompetitor	-.058868	.037602	126.725	-1.566	.120	-.133277	.015540
1.00	Intercept	-.923241	1.671050	10.020	-.552	.593	-4.645579	2.799097
	Acutebeds	.000257	.000516	11.765	.499	.627	-.000869	.001384
	NoCompetitor	-.004611	.369960	9.569	-.012	.990	-.833994	.824772

Percentage of patients receiving antibiotic treatment for more than 3 days after debridement

Hosp2	Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
.00	Intercept	2.216668	.296544	110.262	7.475	.000	1.629003	2.804334
	Acutebeds	.000340	.000332	108.338	1.023	.309	-.000319	.000999
	NoCompetitor	-.071784	.056114	113.366	-1.279	.203	-.182952	.039384
1.00	Intercept	3.383295	1.116780	11.629	3.030	.011	.941410	5.825180
	Acutebeds	-.000234	.000326	11.940	-.717	.487	-.000943	.000476
	NoCompetitor	-.081816	.249614	11.567	-.328	.749	-.627945	.464312

Table 4.21 to Table 4.27

Association between acute bed size, number of hospitals in the same area and quality for hospital levels (1= medical centers, 2 = regional hospitals, 3= district hospitals)

Emergency department visit rate for Acute Myocardial Infarction (AMI) patients who returned to the hospital within 3 days after discharge

Type3	Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
1.00	Intercept	-1.502103	.925499	14.961	-1.623	.125	-3.475210	.471004
	NoCompetitor	.150228	.107105	15.817	1.403	.180	-.077038	.377493
	Acutebeds	.000132	.000573	14.937	.231	.821	-.001090	.001354
2.00	Intercept	-.265068	.598207	48.554	-.443	.660	-1.467490	.937355
	NoCompetitor	-.063364	.088569	49.622	-.715	.478	-.241293	.114565
	Acutebeds	.000833	.000648	48.149	1.285	.205	-.000470	.002137
3.00	Intercept	-1.163298	.751876	63.481	-1.547	.127	-2.665579	.338984
	NoCompetitor	-.094138	.143103	63.264	-.658	.513	-.380084	.191807
	Acutebeds	.000580	.002420	62.564	.240	.811	-.004257	.005417

Rate for outpatients revisiting the same hospital the same day after being treated for the same disease

Type3	Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
1.00	Intercept	-.143182	.186252	16.469	-.769	.453	-.537107	.250743
	Acutebeds	.000218	.000113	18.043	1.930	.069	-1.923956E-5	.000455
	NoCompetitor	.004570	.019010	25.543	.240	.812	-.034540	.043680
2.00	Intercept	-.105778	.131708	59.662	-.803	.425	-.369263	.157707
	Acutebeds	3.025309 E-5	.000145	56.920	.209	.835	-.000260	.000321
	NoCompetitor	-.015957	.018890	67.013	-.845	.401	-.053663	.021748
3.00	Intercept	-.928413	.171849	59.384	-5.402	.000	-1.272237	-.584590
	Acutebeds	.001967	.000558	58.407	3.524	.001	.000850	.003085
	NoCompetitor	-.041777	.032486	61.992	-1.286	.203	-.106716	.023161

The percentage of patients staying in acute beds for more than 30 days

Type3	Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1.00	Intercept	.327813	.167683	16.933	1.955	.067	-.026076	.681701
	Acutebeds	.000360	.000103	17.453	3.487	.003	.000143	.000578
	NoCompetitor	-.023215	.018549	20.193	-1.252	.225	-.061883	.015453
2.00	Intercept	-.229471	.181188	54.606	-1.266	.211	-.592638	.133696
	Acutebeds	.000496	.000199	52.405	2.498	.016	9.774531E-5	.000895
	NoCompetitor	.017398	.026195	59.587	.664	.509	-.035007	.069804
3.00	Intercept	-1.094775	.324645	53.146	-3.372	.001	-1.745889	-.443662
	Acutebeds	.003043	.001053	52.423	2.889	.006	.000930	.005156
	NoCompetitor	.003304	.061785	53.643	.053	.958	-.120586	.127194

Percentage of patients staying in emergency room (ER) for more than 48 hours before being admitted

Type3	Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1.00	Intercept	.941577	.905625	16.428	1.040	.314	-.974207	2.857362
	Acutebeds	.000528	.000552	17.736	.958	.351	-.000632	.001688
	NoCompetitor	-.017095	.094347	23.853	-.181	.858	-.211881	.177690
2.00	Intercept	-1.875139	.557497	50.548	-3.363	.001	-2.994605	-.755674
	Acutebeds	.000746	.000607	49.452	1.229	.225	-.000474	.001966
	NoCompetitor	-.130531	.081717	52.727	-1.597	.116	-.294454	.033391
3.00	Intercept	-3.933512	.499853	57.565	-7.869	.000	-4.934236	-2.932787
	Acutebeds	.004780	.001622	56.808	2.948	.005	.001532	.008027
	NoCompetitor	-.043683	.095133	58.072	-.459	.648	-.234107	.146741

Percentage of ER visits of patients who return to the hospital after 3 days of discharge

Type 3	Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1.00	Intercept	.911937	.148184	15.382	6.154	.000	.596771	1.227102
	Acutebeds	-.000177	9.133425E-5	15.877	-1.940	.070	-.000371	1.657328E-5
	NoCompetitor	.024330	.016387	18.490	1.485	.154	-.010032	.058691
2.00	Intercept	.249134	.388272	54.237	.642	.524	-.529226	1.027494
	Acutebeds	.000378	.000425	52.309	.889	.378	-.000475	.001231
	NoCompetitor	-.019387	.056351	58.319	-.344	.732	-.132172	.093399
3.00	Intercept	-1.114538	.558320	59.698	-1.996	.050	-2.231460	.002384
	Acutebeds	.000898	.001819	58.882	.494	.623	-.002741	.004538
	NoCompetitor	.064466	.105550	62.425	.611	.544	-.146496	.275429

Percentage of patients returning to ER the same day after being treated in the ER

Type 3	Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1.00	Intercept	-.472980	.672669	17.342	-.703	.491	-1.890058	.944098
	Acutebeds	-.000679	.000408	18.953	-1.665	.112	-.001533	.000175
	NoCompetitor	-.009558	.068706	26.543	-.139	.890	-.150645	.131530
2.00	Intercept	-1.374983	.329581	53.793	-4.172	.000	-2.035812	-.714154
	Acutebeds	.000412	.000361	51.684	1.141	.259	-.000313	.001137
	NoCompetitor	-.029565	.047702	58.475	-.620	.538	-.125034	.065905
3.00	Intercept	-.989104	.367961	57.051	-2.688	.009	-1.725918	-.252291
	Acutebeds	-.000144	.001196	56.249	-.121	.904	-.002540	.002251
	NoCompetitor	-.132547	.069910	58.141	-1.896	.063	-.272480	.007385

Percentage of patients receiving antibiotic treatment for more than 3 days after debridement

Type 3	Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1.00	Intercept	1.482096	.238958	19.591	6.202	.000	.982970	1.981222
	Acutebeds	.000395	.000148	19.609	2.670	.015	8.605532E-5	.000704
	NoCompetitor	-.025745	.027513	20.871	-.936	.360	-.082984	.031494
2.00	Intercept	2.774636	.289582	43.788	9.582	.000	2.190942	3.358330
	Acutebeds	-.000249	.000315	43.111	-.791	.433	-.000883	.000386
	NoCompetitor	.001313	.042650	45.245	.031	.976	-.084575	.087201
3.00	Intercept	1.715919	.654269	53.160	2.623	.011	.403713	3.028124
	Acutebeds	.003607	.002120	52.436	1.702	.095	-.000646	.007860
	NoCompetitor	-.172528	.124597	53.366	-1.385	.172	-.422398	.077343

Table 4.28 to Table 4.34

Association between acute bed size, number of hospitals in the same area and quality for hospital location (11= northern Taiwan, 22 = southern Taiwan, 3= central Taiwan)

Emergency department visit rate for Acute Myocardial Infarction (AMI) patients who returned to the hospital within 3 days after discharge

area3	Parameter	Estimate	Std. Error	df	T	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
11.00	Intercept	-.209253	.576317	51.421	-.363	.718	-1.366028	.947521
	NoCompetitor	-.071023	.145908	51.835	-.487	.628	-.363831	.221784
	Acutebeds	.000216	.000462	50.466	.468	.642	-.000712	.001145
22.00	Intercept	-2.327640	.611350	51.030	-3.807	.000	-3.554959	-1.100321
	NoCompetitor	.050041	.096922	51.046	.516	.608	-.144532	.244615
	Acutebeds	.001441	.000652	50.526	2.211	.032	.000132	.002750
33.00	Intercept	-.727856	.883970	27.361	-.823	.417	-2.540494	1.084781
	NoCompetitor	.002608	.162257	28.389	.016	.987	-.329556	.334772
	Acutebeds	.001140	.001560	27.295	.730	.471	-.002060	.004340

Rate for outpatients revisiting the same hospital the same day after being treated for the same disease

area3	Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
11.00	Intercept	-.571055	.128777	51.335	-4.434	.000	-.829545	-.312566
	Acutebeds	.000356	.000108	44.016	3.303	.002	.000139	.000572
	NoCompetitor	.016395	.031411	61.613	.522	.604	-.046401	.079192
22.00	Intercept	-.904527	.186408	45.622	-4.852	.000	-1.279831	-.529224
	Acutebeds	.000895	.000203	42.429	4.407	.000	.000486	.001305
	NoCompetitor	-.006536	.028643	53.262	-.228	.820	-.063980	.050908
33.00	Intercept	-.504399	.168102	29.206	-3.001	.005	-.848100	-.160697
	Acutebeds	.001102	.000279	38.496	3.944	.000	.000537	.001667
	NoCompetitor	-.056686	.028106	40.864	-2.017	.050	-.113453	8.100286E-5

The percentage of patients staying in acute beds for more than 30 days

area3	Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
11.00	Intercept	-.099995	.165848	47.235	-.603	.549	-.433595	.233605
	Acutebeds	.000527	.000133	45.848	3.951	.000	.000259	.000796
	NoCompetitor	.011915	.041924	48.097	.284	.777	-.072374	.096204
22.00	Intercept	-1.410490	.321480	40.857	-4.387	.000	-2.059802	-.761179
	Acutebeds	.001599	.000346	39.429	4.616	.000	.000899	.002300
	NoCompetitor	.066159	.050073	43.282	1.321	.193	-.034804	.167122
33.00	Intercept	-.429632	.264816	26.967	-1.622	.116	-.973020	.113756
	Acutebeds	.000630	.000463	29.029	1.361	.184	-.000317	.001576
	NoCompetitor	-.023695	.047296	30.400	-.501	.620	-.120232	.072843

Percentage of patients staying in emergency room (ER) for more than 48 hours before being admitted

area3	Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
11.00	Intercept	-2.412576	.576892	48.380	-4.182	.000	-3.572258	-1.252893
	Acutebeds	.001986	.000473	44.113	4.201	.000	.001033	.002939
	NoCompetitor	-.125083	.143644	52.981	-.871	.388	-.413199	.163034
22.00	Intercept	-3.503613	.470738	45.537	-7.443	.000	-4.451420	-2.555807
	Acutebeds	.004060	.000506	44.390	8.028	.000	.003041	.005079
	NoCompetitor	-.073655	.073657	47.064	-1.000	.322	-.221828	.074517
33.00	Intercept	-4.145016	.500032	27.242	-8.290	.000	-5.170569	-3.119463
	Acutebeds	.002431	.000881	27.920	2.759	.010	.000626	.004235
	NoCompetitor	.035488	.090772	29.181	.391	.699	-.150112	.221088

Percentage of ER visits of patients who return to the hospital after 3 days of discharge

area3	Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
11.00	Intercept	.690973	.155053	59.658	4.456	.000	.380785	1.001162
	Acutebeds	.000158	.000125	57.781	1.262	.212	-9.240827E-5	.000408
	NoCompetitor	-.023413	.039153	60.956	-.598	.552	-.101705	.054878
22.00	Intercept	-.302898	.298336	41.217	-1.015	.316	-.905304	.299509
	Acutebeds	.000720	.000322	39.778	2.239	.031	6.999630E-5	.001370
	NoCompetitor	.025565	.046467	43.660	.550	.585	-.068104	.119234
33.00	Intercept	-3.850845	.711602	26.623	-5.412	.000	-5.311902	-2.389788
	Acutebeds	.004082	.001230	30.152	3.318	.002	.001570	.006594
	NoCompetitor	.120830	.125102	31.668	.966	.341	-.134100	.375759

Percentage of patients returning to ER the same day after being treated in the ER

area3	Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
11.00	Intercept	-1.286007	.287794	49.473	-4.469	.000	-1.864210	-.707804
	Acutebeds	-.000128	.000235	45.892	-.547	.587	-.000601	.000344
	NoCompetitor	-.064530	.071983	53.022	-.896	.374	-.208907	.079848
22.00	Intercept	-1.804828	.342479	43.163	-5.270	.000	-2.495426	-1.114229
	Acutebeds	.000529	.000370	41.371	1.429	.161	-.000218	.001276
	NoCompetitor	-.036337	.053112	46.618	-.684	.497	-.143207	.070533
33.00	Intercept	-.546973	.306417	27.055	-1.785	.085	-1.175629	.081682
	Acutebeds	.000619	.000534	29.407	1.158	.256	-.000473	.001711
	NoCompetitor	-.057622	.054556	30.806	-1.056	.299	-.168917	.053674

Percentage of patients receiving antibiotic treatment for more than 3 days after debridement

area3	Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
11.00	Intercept	2.170912	.437144	43.956	4.966	.000	1.289881	3.051943
	Acutebeds	.000240	.000354	41.640	.676	.503	-.000475	.000954
	NoCompetitor	-.011656	.109979	45.928	-.106	.916	-.233040	.209729
22.00	Intercept	2.137480	.545025	41.711	3.922	.000	1.037349	3.237612
	Acutebeds	.000216	.000584	40.909	.371	.713	-.000963	.001396
	NoCompetitor	-.024086	.085528	42.447	-.282	.780	-.196635	.148462
33.00	Intercept	2.215747	.598343	28.787	3.703	.001	.991603	3.439890
	Acutebeds	.001042	.001056	28.942	.987	.332	-.001118	.003202
	NoCompetitor	-.221248	.109420	30.176	-2.022	.052	-.444658	.002162

Figure 4.1 Map of Taiwan (Source: https://commons.wikimedia.org/wiki/File:Taiwan_ROC_political_divisions_labeled.svg).

CHAPTER 5:

EFFECTS OF HOSPITAL MERGER, OWNERSHIP, LEVEL, AND LOCATION ON HOSPTIAL COSTS: EVIDENCE FROM TAIWAN

Abstract

Background: In recent years, the NHI has implemented various measures to contain costs such as reducing drug prices, establishing a sliding scale of outpatient payments when providers exceed a specified number of patients seen, eliminating subsidies, and implementing DRG system (Cheng, March 2015). However, the long-term sustainability of the NHI is questionable as Taiwan is now facing a growing aging population and decreasing family size (Liu and Shen, 2015). Thus, finding out the potential factors that may influence hospital costs and derive policy attention to address the issues driving-up hospital costs may contribute to the long-term survival of the program. As such, this study aims: 1) To identify the factors that may affect hospital costs; 2) To add to the existing limited literature on the association of hospital factors with hospital costs.

Methods: The study includes hospital level data from 2012 to 2014 compiled by the Ministry of Health and Welfare. The data contains a total number of 106 hospitals that are located in northern, central, and southern Taiwan. The study employs the General Linear Mixed Model (GLMM) to examine the relationship between hospital costs and hospital factors in terms of time, merger, ownership, location, occupancy rate, the number of acute beds, and the number of competitors. The main dependent variable is the total hospital operating costs.

Results: The results indicate that the number of acute beds, the occupancy rate of acute beds, and year are significantly associated with hospital costs ($P < 0.05$). However, the number of competitors, merged/non-merged hospitals, ownership, and location are insignificantly associated with hospital costs ($P > 0.05$).

Conclusions: Findings in this study may imply that hospital costs could be influenced by public policies and practices. However, further investigation based on a larger sample of hospitals with a longer period of time is important. This would support the assessment of whether the factors identified in this study provide consistent results.

Introduction and Background

The implementation of the National Health Insurance (NHI) program in 1995 and the practice of the global budget system that caps total NHI expenses in 2002 have combined to put unprecedented pressure on Taiwan's hospitals. Many have sought ways to manage costs while maintaining a high quality of care. Such pressure has forced many small hospitals to exit the market and the remaining hospitals to become bigger in size (Lin, 2012). This has also led the government to implement the third healthcare reform – the three mergers formed by several city hospitals: a merger of 10 city hospitals located in Taipei City in 2005, a merger of two city hospitals in New Taipei City in 2004, and merger of two city hospitals in Kaohsiung City in 2002. Moreover, it has been 21 years since Taiwan implemented the NHI system. The NHI has been seeking ways to contain its costs as it has suffered financial deficit since its implementation. It was only with the introduction of the second increase in the premium rate in 2010 and the inclusion of non-payroll income as new sources of premiums (i.e. the second generation NHI) in 2013, that the NHI finally overturned its deficits to surpluses (Lu et al., 2016; Chang, May 2015). In recent years, the NHI has implemented various measures to contain costs such as reducing drug prices, establishing a sliding scale of outpatient payments when providers exceed a specified number of patients seen, eliminating subsidies, and implementing DRG system (Cheng, March 2015). However, the long-term sustainability of the NHI is questionable as Taiwan is now facing a growing aging population and decreasing family sizes (Liu and Shen, 2015). Thus, finding out the potential factors that may influence hospital costs and derive policy attention to address the issues driving up hospital costs may contribute to the long-term survival of the program. As such, this study aims: 1) To identify the factors that may affect hospital costs; 2) To add to the existing limited literature on the association of hospital factors with hospital costs.

Besides hospital merger or competition, empirical research also demonstrates other factors such as ownership, hospital levels, hospital and number of beds that may influence hospital costs (Chang et al., 2004; Hung and Chang, 2008). In the U.S., research examining factors influencing hospital costs such as the effects of hospital competition, mergers, and ownership demonstrates mixed results. However, in Taiwan, research pertaining to the factors that affect hospital costs is limited. This may due to the limited access to hospital and patient level data. Furthermore, the cost savings in this study refer to the savings or reduction in costs to the hospital, not to the consumers. Ownership refers to either private or public owned. Hospital level includes medical center, regional hospitals, and district hospitals. This chapter is organized as follows: literature review, methods, results, discussion, and conclusion.

Literature review

Literature on cost savings associated with hospital merger

Similar to the results of empirical studies on the impact of competition associated with quality of care, findings of empirical research on the effects of hospital mergers associated with hospital costs are also inconclusive. Based on the author's research, there is no research on hospital mergers in Taiwan published in the U.S. or U.K.

However, there is one dissertation written in Chinese that focuses on merger effects associated with costs in Taiwan (Wang, 2008). Wang (2008) applies linear regression to examine the association among the salary expenses, non-medical supply expenses, medical supply expenses, and total operating costs of the Taipei City Hospital. Wang's (2008) findings suggest that the hospital's total operating costs are significantly associated with the medical supply expenses. Moreover, Wang (2008) also applies student's *t* statistics to examine the changes in total operating costs before and after the merger. Her findings indicate that the hospital's total operating costs reduced significantly after the merger.

In the U.S., there are various studies that evaluate cost reduction associated with hospital mergers. (Alexander et al., 1996; Connor et al., 1997; Dranove, 2003; Spang et al., 2001; Kusserow, 1992). Some researchers have even found that the cost savings produced by hospital mergers can be significant (Vogt & Town, 2008). The U.S. Department of Health and Human Services (Kusserow, 1992) examines the percentage change in total operating costs, revenues, and patient volume of two groups of merged and non-merged hospitals that are geographically similar. The two groups of merged and non-merged hospitals include a random selection of eleven hospital mergers from the American Hospital Association (AHA) list in 1987 and a control group of hospitals with similar geographic characteristics (Ibid). The author applies the Wilcoxon Rank Sum and Median tests to compare the two groups and concludes that while the merged hospitals generate cost savings, they are indifferent in terms of growth in revenues and patient volume (P.1, Ibid).

The longitudinal study done by Alexander et al. (1996) also reports reduced costs. Alexander et al. (1996) apply a multiple time-series design with a longitudinal assessment of changes in scale of activity, staffing practices, and operating efficiencies before and after the merger (1996). The authors identify 92 mergers that took place between 1982 and 1989 from the AHA Annual Survey of Hospitals. They find that hospital mergers lead to improved operating efficiency as increases in the ratio of total expenses per adjusted admission for non-merging hospitals are larger than those of the merging groups. Furthermore, the decline of occupancy rate is significantly less for the merging hospitals than those of the non-merging hospitals (Ibid). However, Alexander et al. (1996) find that utilizing a control group of non-merging hospitals that are randomly drawn may inadequately account for systematic effects such as high penetration of managed care and the status of the hospitals (Capps, 2005).

Connor et al. (1997) apply a multivariate analysis in their longitudinal study to examine 122 hospital mergers listed in the AHA Annual Survey and analyze changes in hospital costs and prices before and after mergers from 1986 to 1994. The researchers compare the costs and prices of merged hospitals to those of the control group consisting of 3,500 non-merged hospitals. The researchers report that the growth in operating costs and prices of all merging hospitals are 7.2 and 7.1 percentage points, respectively. This is lower than those of non-merging hospitals (Conner et al., 1997; Spang et al., 2001). Their research provides evidence that horizontal hospital mergers lead to savings in annual operating expenses and such savings lead to lower prices for consumers (Connor et al., 1997). In their subsequent research (1998), they apply a multivariate analysis to investigate operating costs and prices associated with hospital mergers in relation to market concentration (Connor et al., 1998). Connor et al. (1998) also find cost savings associated with hospital mergers and conclude that horizontal hospital mergers generate an average cost savings of 5% (1998). Moreover, the authors indicate that these cost savings are greater for mergers of similar-size hospitals but the cost savings are not as pronounced in more concentrated markets (Connor et al., 1998; Ho and Hamilton, 2000).

Spang et al. (2001) update and expand the work of Connor et al. (1997) to examine the changes of total hospital costs and prices for merging and non-merging hospitals from the AHA Annual Survey from 1989 to 1997 (2001). However, unlike the study of Connor et al. (1997), Spang et al. (2001) divide the non-merging hospitals into two groups: non-merging rival hospitals and non-merging non-rival hospitals. According to the researchers (2001), this allows them to examine the merger effects more clearly by comparing merging hospitals with their rivals that are located in the same market and encounter similar conditions (Spang et al., 2001). Similar to the findings of Connor et al. (1997, 1998), the findings of Spang et al. (2001) indicate that both the growth of costs and prices for merging hospitals are lower (10 and 7.9 percentage points respectively) than those of non-merging hospitals (Ibid). Moreover, Spang et al. (2001) find that in more competitive markets, merger-related cost and price savings are larger when merging hospitals are compared with their non-merging non-rivals but are smaller when compared with their non-merging rivals (2001). Furthermore, Spang et al. (2009) conduct a multivariate analysis to examine the direct effects of mergers on total costs and prices of 4,140 urban hospitals which consist of 125 mergers, 1040 system acquisitions, and 2995 non-merging hospitals in the AHA Annual Survey from 1988 to 1997 (2009). Spang et al. (2009) find that merging hospitals in general have higher costs and prices than average hospitals before the merger and suggest that such results may be their rationale for merging (2009). However, the researchers conclude that the cost savings and lower prices that result from mergers are only exhibited among for-profit hospitals in highly competitive markets (2009).

Dranove (1998) applies semiparametric methods to examine the efficiency gains of fourteen non-revenue producing cost centers for merging hospitals. Dranove (1998) indicates that small hospitals with approximately 100 beds are more likely than larger merging hospitals to obtain significant benefits from economies of scale in non-revenue producing cost centers. Furthermore, even if one of the merging hospitals is small, nominal rises in price or cost margins may outweigh the gains in efficiency (1998). Moreover, the type of mergers such as system mergers may influence the effects of hospital mergers associated with costs. The following studies illustrate this aspect.

Dranove and Lindrooth (2003) build on prior studies such as Dranove et al. (1995, 1996), and Connor et al. (1997, 1998) to examine whether hospital mergers result in cost savings by analyzing changes of system consolidation and mergers. They use parametric difference-in-difference (DID) approach to examine the factors that impact costs (Dranove and Lindrooth, 2003). The researchers compare 122 merging hospitals from the AHA Annual Survey to a sample of 10 pseudo-consolidations of non-merging hospitals with the same characteristics during 1988 and 1996 (2003). Dranove and Lindrooth (2003) conclude that while system consolidations do not result in cost savings, mergers on average lead to significant cost savings of 14% which can persist even two, three and four years after the merger. Moreover, Dranove and Lindrooth (2003) point out that capacity reduction may be the reason for the cost savings.

Burns et al. (2015) also examine the effects of system mergers on hospital operating costs. The authors analyze 4,000 hospitals located in the fifty states from the AHA Annual Survey from 1998 to 2010. They also use the data from the Centers for Medicare and Medicaid Services (CMS), the Area Resource File (ARF) and Healthcare Cost Report Information System (HCRIS) (Burns et al., 2015). Burns et al. (2015) apply the DID analysis to examine whether system hospitals result in lower operating costs over time. They also analyze the association between system size and hospital operating costs. Burns et al. (2015) conclude that system hospitals do not result in lower operating costs and larger hospital systems (i.e. with more than 30 or more hospitals) generate significantly higher average operating costs than all other hospitals. Moreover, Burns et al. (2015) indicate that the lack of capabilities to centralize governance and develop shared services organizations that can generate cost savings may be one of the reasons for the failure of multihospital systems to reduce operating costs.

Harrison (2011) provides a different view from the studies mentioned above. She identifies a total of 104 mergers from the AHA Survey of Hospitals from 1984 to

1998 to examine whether the merging hospitals obtain economies of scale by comparing their potential post-merger cost savings 3 years post-merger with their realized cost savings over the period and during the first, second, and third year after the merger (Harrison, 2011). Harrison (2011) points out that the cost savings for the merging hospitals in the year after the merger are the largest but they decrease in subsequent years after the merger (Ibid).

As illustrated in some studies, system mergers or mergers may influence hospital costs. However, the findings of most of the studies in general conclude that hospital mergers lead to the potential benefits such as cost and price savings and enhanced efficiency, although the cost savings may decline overtime.

Literature on the association of hospital ownership, level on hospital costs

Chang et al., (2004) investigate the association between hospital ownership and operating efficiency by using the data from the surveys of hospitals compiled by the MOHW in both 1996 and 1997. The total number of hospitals in their sample includes 43 regional and 440 district hospitals in 1996 and 44 regional and 429 district hospitals in 1997. They employ an output-based approach which measures the amount of output that can be obtained from a given level of input and the BCC model to estimate the efficiency indices. Chang et al., (2004) use inputs such as number of beds, number of physicians, number of nurses, and number of supporting medical personnel and outputs such as number of patient days, number of clinic or outpatient visits, and number of patients receiving surgery. Chang et al., (2004) find that public district hospitals employ more inputs and generate more outputs than private district hospitals. However, the results are mixed for the regional hospitals. Moreover, change et al., (2004) find that private regional and district hospitals are more efficient operationally than public regional and district hospitals.

Hung and Chang (2008) examine the factors associated with the increased hospital costs after the implementation of the NHI program by using data from the NHI Database and the Taipei Health Information Indices Database from 1990 to 2001. Their sample includes 12 regional hospitals located in Taipei City. Hung and Chang (2008) find that the costs of all hospitals have significantly increased since the implantation of NHI. Moreover, Hung and Chang (2008) point out that the factors that cause the costs of all the hospitals in the sample to increase include the increasing number of patients aged 65 and above, procurement of new medical technology, length of stay, and type of diseases. For future research, Hung and Chang (2008) suggest examining the association between hospital factors and costs based on larger sample of public hospitals.

Chiang et al. (2014) investigate the association between hospital factors and hospital financial performance, using operating margin and return on fixed assets as financial performance indicators and dependent variables. Their sample includes 144 hospitals, including 10 medical centers, 22 regional hospitals, and 112 district hospitals. Of which, there are 67 public hospitals, 49 private hospitals, and 28 hospitals operated by charitable foundations. Moreover, 50 of the hospitals are located in northern Taiwan, 21 in central, and 7 in the eastern Taiwan. They employ one-year hospital level data such as inpatient surgery rate, fixed asset used, average length of stay, fixed asset ratio, occupancy rate, and amount of hi-tech equipment purchased. Chiang et al. (2014) find no significant association between hospital scale and level with the profitability indicators. Moreover, Chiang et al. (2014) find a negative correlation between length of stay and operating margin, suggesting that increasing the average length of stay can result in increased costs and decreased operating margin. Furthermore, Chiang et al. (2014) find that a significant and negative association between fixed assets ratio and return on fixed assets. Chiang et al. (2014) point out that for each unit increase in investments in fixed assets, a hospital's return is decreased by 3.1%. This result is inconsistent with the general belief that increasing investment in fixed assets can increase hospital returns (Chiang et al., 2014). In addition, Chiang et al. (2014) does not find a significant association between hospital location and profitability.

Liu et al. (2014) examine the association between cardiologist service volume, hospital level, and percutaneous coronary intervention with hospital costs and acute myocardial infarction (AMI) mortality. They use the National Health Insurance Research Database to identify 7,267 AMI patients treated in medical centers and regional hospitals in Taiwan between the period of 1997 and 2010. Liu et al. (2014) find that medical centers or regional hospitals with high volume in cardiologist service or percutaneous coronary intervention have low mortality rates. Thus Liu et al. (2014) indicate that hospital level is not a factor but rather the service volume is the factor that impacts quality and hospital costs. However, Liu et al. (2014) find that a higher volume of cardiologist service and number of percutaneous coronary intervention performed are associated with increased hospital costs. Liu et al. (2014) illustrate that medical centers with high cardiologist service volume and less percutaneous coronary intervention performed are the least cost-effect, resulting in higher medical costs and lower reduction in mortality rate. In order to improve quality of care and to reduce costs, Liu et al. (2014) suggest that policymakers make careful financial considerations before developing the proficiency for percutaneous coronary intervention of all hospitals especially medical centers that have higher cardiologist service volumes. Furthermore, for future research, Liu et al. (2014) suggest that further study on the association would help improve the healthcare economy in Taiwan.

Methods

Data

The data used in this study is the same as the one used in the study in Chapter 4. Based on the availability of the data compiled by the Ministry of Health and Welfare (MOHW), the study includes hospital variables such as merged/non-merged hospitals, ownership (i.e. public/private hospitals), the acute bed number, the number of hospitals in the same city, location, the average occupancy rate, and time. In addition, for measuring the intensity of competition such as HHI, data on hospital discharges is unavailable for all hospitals and thus the study only applies the number of hospitals in the marketplace to measure density of competition. Because MOHW only starts to compile hospital financial data from 2013, the study includes hospital level data from 2012 to 2014. The data contains a total number of 106 hospitals that are located in northern, central, and southern Taiwan. The northern region includes Taipei City, New Taipei City, Keelung City, and Yilan City. The central region includes Taichung City, Changhwa City, and Nantou City. The southern region includes Kaohsiung City and Pingtung City. These locations are chosen because they have Taiwan's highest populous cities - New Taipei City, Kaohsiung City, Taichung City and Taipei City (World Population Review, 2016). Moreover, of the 106 hospitals, there are 15 medical centers, 43 regional hospitals, and 48 district hospitals. From this group, there are 35 public and 71 private hospitals; 42 are located in northern Taiwan, 40 in southern Taiwan, and 24 in central Taiwan.

Statistical analysis

Statistical analysis is performed using SPSS version 23.0 (SPSS INC., Chicago, IL, USA). The study employs the Generalized Linear Mixed Model (GLMM) to examine the relationship between hospital costs and hospital factors in terms of time, merged/non-merged, ownership, location, the number of competitors, the number of acute beds, and occupancy rate of acute beds. The main dependent variable is the total hospital operating costs. Because the data on the total operating costs is skewed toward larger values, the study uses the Gamma regression which assumes a gamma distribution with a log link (Garson, 2013). The covariance structure of First-Order Autoregressive (AR1) is applied. AR1 is used to represent certain correlation between present and future values and the first-order one indicates that the immediately preceding value has a direct impact on the current value (Campbell, 2006; Moffatt, 2015). Moreover, the Bonferroni's method is used for multiple comparisons. It is used to avoid the chances of obtaining false-positive results (type I errors) when performing multiple pair wise tests on the same data set (Napierala, 2016). Significance of association is defined as $P < 0.05$.

Subgroups are created and analyzed separately. This is for examining the association between the number of acute beds, occupancy rate, the number of competitors, time and hospital costs for each group of hospitals. There are four subgroups: 1. Merged and non-merged hospitals; 2. Private and public hospitals; 3. Medical centers, regional hospitals, and district hospitals; 4. Northern, southern, and central Taiwan hospitals.

Results

Table 5.1 provides summary statistics for the total operating costs in 2012, 2013, and 2014. During this period, the (mean) total operating costs depict a rising trend. Table 5.2 to Table 5.5 are the summary statistics for the total operating costs from this period based on merged/non-merged, hospital ownership, hospital levels, and location. Table 5.6 contains the statistical results of the association between hospital costs and the number of competitors, the number of acute beds, the occupancy rate of acute beds, merger, ownership, location and year. Table 5.7 provides subgroup analysis on the association of hospital size, occupancy rate, competition, time and hospital costs based on the four categories: merged/non-merged, hospital ownership, levels, and location. Figure 5.1 to 5.4 provide comparisons of total operating costs from 2012 to 2014 between/among each group of hospitals: merged/non-merged, private/public, medical centers/regional hospitals/district hospitals, and northern Taiwan hospitals/southern Taiwan hospitals/central Taiwan hospitals.

The association between merged/non-merged hospitals, the number of competitors, the number of acute beds, occupancy rate of acute beds, ownership, location, time and hospital costs

Merged and non-merged hospitals are insignificant in the regression results ($P > 0.05$). However, non-merged hospitals have insignificantly higher costs than merged hospitals. Also, the number of competitors and hospital costs are insignificantly positive ($P > 0.05$). This suggests that the more competitors in the marketplace, the higher hospital costs will be. However, the association between the number of acute beds and hospital costs is significant and positive ($P< 0.05$). This suggests that the higher the number of the acute beds, the higher the hospital costs. Moreover, the association between the occupancy rate of acute beds and hospital costs is significantly positive. The result indicates that the higher the occupancy rate, the higher the hospital costs. In contrast, hospital ownership is insignificantly associated with hospital costs; private hospitals demonstrate insignificant higher costs than public hospitals. Hospital location is insignificantly associated with hospital costs. Yet hospitals in northern Taiwan depict the highest costs, followed by hospitals in central

Taiwan, and then hospitals in southern Taiwan (Figure 5.4). Furthermore, time has significantly positive association with hospital costs. This suggests that the total operating costs of all the hospitals included have grown throughout these years and they are likely to continue to grow as time goes by.

Subgroup analysis: association between the number of acute beds, occupancy rate, the number of competitors, time and hospital costs for merged/non-merged hospitals, private/public hospitals, medical centers/regional hospitals/district hospitals, northern/southern/central Taiwan hospitals

Researchers illustrate that hospital size measured by the number of beds, occupancy rates, and competition, can affect hospital costs (Coyne, 2009; Fard et al., 2010; Fournier and Mitchell, 1992). Also, research finds that in terms of location, although rural hospitals have higher costs resulting from the rise of uncompensated care, they are very efficient in balancing their other costs, so that their financial performance is equivalent to that of urban hospitals (Schumann, 2008). Based on the findings from the literature, the study performs subgroup analysis to examine the association between the variables such as number of acute beds, occupancy rate, thee number of competitors, time, and hospital costs of each group in the following section.

Merged/non-merged hospitals

For both merged and non-merged hospitals, the association between the number of acute beds, occupancy rate, time and hospital costs is significantly positive ($P <$

0.05). This suggests that the greater the number of beds and occupancy rate, the higher the hospital costs. Moreover, the positively significant association between time and hospital costs indicates that hospital costs increase as time goes by. While the number of competitors and hospital costs are negatively and significantly associated for merged hospitals, they are negatively and insignificantly associated for non-merged hospitals. This suggests that the more competitors the merged hospitals have, the lower their hospital costs will be.

Public/private hospitals

Ownership may have impact on hospital costs due to the production technology the hospital adopts such as centralized management (Fournier and Mitchell, 1992). For private hospitals, the association between the number of acute beds, occupancy rate, the number of competitors and hospital costs is insignificant ($P > 0.05$). However, the association between time and hospital costs is positively significant ($P < 0.05$), suggesting that as time passes, the hospital costs of private hospitals increases. For public hospitals, the association between the number of acute beds, occupancy rate, time and hospital costs is positively significant. Nevertheless, the number of competitors and hospitals costs for public hospitals has a negatively insignificant association.

Medical centers/regional hospitals/district hospitals

For medical centers, the association between the number of acute beds, time and hospital costs is positively significant ($P < 0.05$). However, occupancy rate, the number of competitors and hospital costs are positively insignificant ($P > 0.05$). For regional hospitals, occupancy rate, time and hospital costs have significant and positive associations. Yet the association of occupancy rate, the number of competitors and hospital costs is insignificant. For district hospitals, the number of acute beds, time and hospital costs is significantly and positively associated, while occupancy rate, the number of competitors and hospital costs is insignificantly associated.

Northern/Southern/Central Taiwan hospitals

For northern and southern Taiwan hospitals, the number of acute beds, occupancy rate, time and hospital costs have positive and significant associations ($P < 0.05$). Therefore, the higher number of beds and occupancy rate, then the higher the costs. Moreover, costs increase with time. For both northern and southern Taiwan hospitals, although the association between the number of competitors and hospital costs is insignificant, the direction is opposite. For northern Taiwan hospitals, the association is negative, suggesting that the more the competitors, the lower the hospital costs. In contrast, for southern Taiwan hospitals, the association is insignificant yet positive, suggesting that the more the competitors, the higher the hospital costs. Finally, hospitals in central Taiwan demonstrate a significant association between the number of acute beds, time and hospital costs. However, the association between the number of acute beds and hospital costs is negatively significant, suggesting that the higher the number of acute beds, the lower the hospital costs.

Discussion

The study examines the association between hospital costs and merged/non-merged hospitals, the number of competitors, hospital ownership, occupancy rate, location, the number of acute beds, and time. The results indicate that the number of acute beds, the occupancy rate of acute beds, and year are significantly associated with hospital costs.

The number of acute beds, occupancy rate, and time (Table 5.6): The results are consistent with previous research that demonstrates larger scale hospitals such as medical centers and regional hospitals result in higher operating costs (Lin, 2015). The results also reflect the current situation in Taiwan where the delivery of medical services is concentrated in large hospitals and high bed occupancy rates occur mainly in these large hospitals (Cheng, Y.W., 2015; Okma and Crivelli, 2010; Wang and Cheng, 2005). However, whether or not larger hospitals incurring higher costs as found in this study is due to inefficiency would require further investigation based on more detailed data. Moreover, the association between year and hospital costs is significantly positive. This result also points out the continuously rising healthcare expenditures in Taiwan. In view of the growing aging population, and increasing medical needs, healthcare expenditures are expected to continue to grow (Lin, 2015; Hung and Chung, 2008). Thus identifying the drivers of the escalating costs is crucial in finding effective cost containment strategies.

In the subgroup analysis on the association of bed size, occupancy rate, time and hospital costs based on merged/non-merged, ownership, levels, and location, for merged and non-merged hospitals, their costs have significant and positive association with the number of acute beds, occupancy rate, and time. In terms of hospital ownership, the association is significantly positive only for public hospitals. The costs of private hospitals do not have significant association with bed size and occupancy rate. This may be due to the fact that private hospitals do not receive the same public subsidies that public hospitals do. Thus private hospitals, regardless of their size or occupancy rate, would practice in accordance with their hospitals' financial benefits to reduce their costs and increase profitability by whatever means (Lin et al., 2003; Chang et al., 2004). However, private hospitals incur higher costs than public hospitals. This may be due to the flexibility of private hospitals to acquire new technology. They do not need to go through the Government Budget Act that public hospitals are required to do, and thus they can increase their spending in new technology (Hung and Chang, 2008). In terms of hospital level, the results are mixed which is parallel to the inconsistent consensus on the association of hospital costs with hospital level and size (Chiang et al., 2014). For instance, for medical centers, regional hospitals and district hospitals, hospital costs are positively and significantly associated with time. However, only for medical centers and district hospitals, are hospital costs significantly and positively associated with the number of acute beds. For regional hospitals, costs have positive and significant association with occupancy rate and time but not with bed size. In terms of location, for hospitals in northern Taiwan, and southern Taiwan, the association of hospital costs with bed size and time is significantly positive, while the association is significantly negative for those in central Taiwan. This may suggest that larger central Taiwan hospitals have achieved economies of scale, and they are more efficient in controlling their costs than hospitals in the other two locations.

Hospital ownership (Table 5.6): The association found in this study is insignificant ($P > 0.05$). Also, the results found in this study in regard to the association between hospital ownership and hospital costs are inconsistent with previous research that demonstrates public hospitals incur larger costs than private hospitals (Lin et al., 2003; Fournier and Mitchell, 1992). However, most of the previous literature that examines such associations is based on treatments for certain categories of diseases and thus only represents specific costs. Indeed, private hospitals own 70% of the hospital beds in Taiwan (Okma and Crivelli, 2010). That private hospitals have higher costs may be explained by their spending more on procurement and upgrading of medical equipment and technology than public hospitals (Hung and Chang, 2008).

Merged/non-merged hospitals, number of competitors (Table 5.6): The associations between merged/non-merged hospitals, the number of competitors and hospital costs are insignificant. The coefficient for the number of competitors is 0, suggesting that the number of competitors does not have an impact on hospital costs. Merged hospitals depict insignificantly lower costs than non-merged hospitals. This is consistent with literature (Alexander et al., 1996; Connor et al., 1997; Dranove, 2003; Harrison, 2011; Spang et al., 2001; Vogt & Town, 2008;).

Hospital location (Table 5.6): The association between hospital costs and location is insignificant. This is inconsistent with the literature (Cutler, 2013; Sinay, 1998). However, comparing the costs of hospitals in the three different locations, the results show that hospitals in northern Taiwan have the highest costs. This is supported by existing research that finds that hospitals in northern Taiwan have a longer length of stay due to the higher density of hospitals in northern Taiwan and because of fierce competition, so they need to provide more care to maintain their patient volume (Lin et al., 2003). Thus they incur higher costs. However, promoting patient satisfaction may conflict with improving patient health outcomes and may result in increased hospital costs (Nuckols et al., 2013). Further research that includes average length of stay into the investigation on the association between hospital costs and hospital factors is therefore important.

While cost containment is important, sustaining good quality of care is also crucial. Researchers stipulate that hospitals can maintain low costs or efficiency while delivering high quality of care (Larsson, S., 2013; Porter, M. and Teisberg, E., 2004). Furthermore, discharging patients earlier does not have a long-term detrimental impact on inpatient quality of care (Chen et al., 2010; Chang et al.; 2011). However, in general, concentrating on cost reduction often leads to deterioration in quality of care (Ward, 2016). In Taiwan, the current practice seems to emphasize cost containment more than improving quality of care (Chang, 2011). As policy makers implement policies limiting costs generated by healthcare providers to contain healthcare expenditures, engaging patients to improve outcomes and reduce waste of medical resources is equally crucial in containing the rising costs efficiently. While healthcare providers should be accountable for providing good quality of care and minimize medical waste, both providers and patients should practice cost containment in order to ensure the long-term sustainability of the program. For example, the consensus that a shorter length of stay may mean worse quality of care needs to be changed as decreasing the length of stay for certain conditions can prove to decrease hospital costs without jeopardizing quality of care (Katz, 2010).

This research has several limitations. The research may also be limited by its small sample size, which is likely to cause the power of econometric tests to be decreased (Spang et al., 2009). As Spang et al. (2009) point out: a small number of observations decreases the power of econometric tests and restricts the researcher's ability to test the significance of effects of the association being studied. Moreover, the non-random selection of the case can lead to selection bias. The inclusion of a greater number of hospitals to increase the sample size would help minimize the problems on generalizability and the power of econometric tests. Due to the limited access to certain hospital data such as average length of stay, the number of employees, the number of registered nurses, case-mixed index, or severity of illness of patients treated in each hospital and patient level data, the scope of the findings in this study is limited. Furthermore, the study relied on the process measures compiled by MOHW that can help the public evaluate hospital quality of care. While such data allows the study to examine associations, it does not provide information on causality.

Conclusion

The study finds that the number of acute beds, the occupancy rate, and time have an impact on hospital costs. This is consistent with the prediction of the study. In particular, for merged and non-merged hospitals, public hospitals, and hospitals in northern and southern Taiwan, the number of acute beds, the occupancy rate, and time have an impact on their costs. Findings in this study may suggest that hospital costs could be influenced by public policies and practices. This study may serve as a foundation for further investigation based on a larger sample of hospitals and longer period of time. This would support the assessment of whether the factors identified in this study provide consistent results and would provide a better understanding of the factors that influence hospital costs.

Table 5.1 Summary statistics of costs from 2012 to 2014 for all hospitals

Statistics§	**2012**	**2013**	**2014**
Mean (S.E.)	151,858 (19,120)	155,730 (19,390)	159,973 (20,601)
Std. Deviation	154,158	158,722	160,904
Minimum	21,364	22,568	24,919
Maximum	620,845	661,362	686,417
Median	73,302	74,386	77,631

§ in USD thousand

Table 5.2 Summary statistics for merged/non-merged hospitals

Statistics§	2012	2013	2014
Merged hospitals			
Mean (S.E.)	172,598 (132,542)	173,415 (130,895)	178,689 (133,514)
Std. Deviation	229,570	226,716	231,254
Minimum	39,506	41,854	44,748
Maximum	437,582	435,203	445,719
Median	40,403	43,186	45,601
Non-merged hospitals			
Mean (S.E.)	150,860 (19,337)	154,901 (19,663)	159,005 (20,909)
Std. Deviation	152,261	157,304	159,239
Minimum	21,364	22,568	24,919
Maximum	620,846	661,362	686,417
Median	73,480	75,103	78,986

§ in USD thousand

Table 5.3 Summary statistics for public/private hospitals

Statistics§	2012	2013	2014
Private hospitals			
Mean (S.E.)	157,377 (22,679)	162,772 (23,365)	159,048 (23,630)
Std. Deviation	141,633	147,777	141,785
Minimum	22,357	22,568	24,919
Maximum	496,383	515,711	556,914
Median	95,057	97,946	100,817
Public hospitals			
Mean (S.E.)	143,580 (34,096)	145,297 (33,886)	161,305 (37,632)
Std. Deviation	173,860	176,078	188,162
Minimum	21,364	25,906	29,854
Maximum	620,846	661,362	686,417
Median	59,290	64,357	66,426

§ in USD thousand

Table 5.4 Summary statistics for medical center/regional/district hospitals

Statistics§	2012	2013	2014
Medical Centers			
Mean (S.E.)	321,205 (40,799)	334,421 (42,369)	349,714 (44,842)
Std. Deviation	158,014	164,094	173,674
Minimum	138,322	142,443	109,020
Maximum	620,846	661,362	686,417
Median	297,528	306,649	318,498
Regional Hospitals			
Mean (S.E.)	109,318 (18,180)	111,837 (18,047)	89,362 (11,999)
Std. Deviation	113,534	115,561	72,990
Minimum	30,787	25,745	28,293
Maximum	448,727	471,073	447,484
Median	67,760	68,515	68,304
District Hospitals			
Mean (S.E.)	71,755 (31,654)	75,661 (33,450)	134,025 (53,847)
Std. Deviation	104,985	110,941	161,543
Minimum	21,364	22,568	24,919
Maximum	359,590	381,152	404,684
Median	28,543	28,235	42,617

§ in USD thousand

Table 5.5 Summary statistics for northern/southern/central Taiwan hospitals

Statistics§	2012	2013	2014
Northern			
Mean (S.E.)	185,986 (35,235)	193,369 (36,229)	203,224 (40,266)
Std. Deviation	179,665	184,733	193,110
Minimum	24,908	25,906	42,167
Maximum	620,845	661,362	686,417
Median	138,660	143,992	155,489
Southern			
Mean (S.E.)	126,796 (26,231)	128,497 (26,634)	137,741 (28,104)
Std. Deviation	123,036	127,733	131,820
Minimum	21,364	22,568	28,293
Maximum	339,762	354,655	445,719
Median	62,654	66,028	67,649
Central			
Mean (S.E.)	132,096 (35,630)	136,161 (35,691)	128,369 (35,249)
Std. Deviation	146,907	151,426	140,998
Minimum	22,419	23,163	24,919
Maximum	359,590	471,072	404,685
Median	67,760	68,769	71,940

Table 5.6 Association between hospital competition, the number of acute beds, occupancy rate, ownership, merger, location, time and hospital costs

Hospital factors	F Statistics	P	Post Hoc Analysis
Number of competitors	0.002	0.966	
Number of acute beds	11.598	0.001	
Occupancy rate of acute beds	16.526	0.000	
Ownership‡	2.207	0.139	Private > Public
Merger§	0.029	0.866	Non-merged > Merged
Location*	1.072	0.345	Northern > Central
Time	263.253	0.000	

‡ includes both public and private hospitals

§ includes both merged and non-merged hospitals

*includes hospitals in northern, central, and southern Taiwan

Table 5.7 Subgroup analysis on association between bed size, occupancy rate, competition, time and hospital costs: based on merged/non-merged, ownership, levels, and locations

Category	Coefficient	*P*-value	95% C.I. Lower	95%C.I. Upper
Merger				
Merged hospitals				
Bed size§	0.001	0.000	0.001	0.001
Occupancy rate	0.002	0.000	0.001	0.002
No of competitors	-0.059	0.000	-0.073	-0.044
Time	0.063	0.000	0.058	0.069
Non-merged hospitals				
Bed size§	0.001	0.000	0.001	0.001
Occupancy rate	0.007	0.000	0.004	0.011
No of competitors	-0.03	0.085	-0.064	0.004
Time	0.049	0.000	0.036	0.062
Ownership				
Private hospitals				
Bed size§	-0.000	0.386	0.000	0.000
Occupancy rate	0.001	0.170	-0.001	0.004
No of competitors	0.001	0.897	-0.017	0.019
Time	0.047	0.000	0.039	0.054
Public hospitals				
Bed size§	0.001	0.000	0.001	0.001
Occupancy rate	0.007	0.000	0.004	0.011
No of competitors	-0.030	0.085	-0.064	0.004
Time	0.049	0.000	0.036	0.062
Levels				
Medical centers				
Bed size§	0.000	0.001	0.000	0.000

Occupancy rate	0.002	0.205	-0.001	0.005
No of competitors	0.011	0.397	-0.015	0.036
Time	0.046	0.000	0.035	0.056
Regional hospitals				
Bed size§	0.000	0.678	0.000	0.000
Occupancy rate	0.004	0.000	0.002	0.007
No of competitors	-0.003	0.802	-0.026	0.020
Time	0.047	0.000	0.039	0.056
District hospitals				
Bed size§	0.002	0.000	0.002	0.003
Occupancy rate	0.001	0.503	-0.002	0.003
No of competitors	-0.001	0.937	-0.020	0.019
Time	0.061	0.000	0.054	0.067
Location				
Northern				
Bed size§	0.001	0.000	0.000	0.001
Occupancy rate	0.004	0.004	0.001	0.006
No of competitors	-0.022	0.087	-0.047	0.003
Time	0.057	0.000	0.048	0.066
Southern				
Bed size§	0.001	0.000	0.001	0.002
Occupancy rate	0.007	0.005	0.002	0.012
No of competitors	0.006	0.697	-0.023	0.034
Time	0.046	0.000	0.028	0.065
Central				
Bed size§	-0.001	0.027	-0.001	-0.0000
Occupancy rate	0.004	0.236	-0.003	0.010
No of competitors	-0.044	0.202	-0.112	0.024
Time	0.042	0.000	0.022	0.063

§ = the number of acute beds

Figure 5.1 Comparisons of total operating costs from 2012 to 2014 between each group of hospitals: merged vs. non-merged

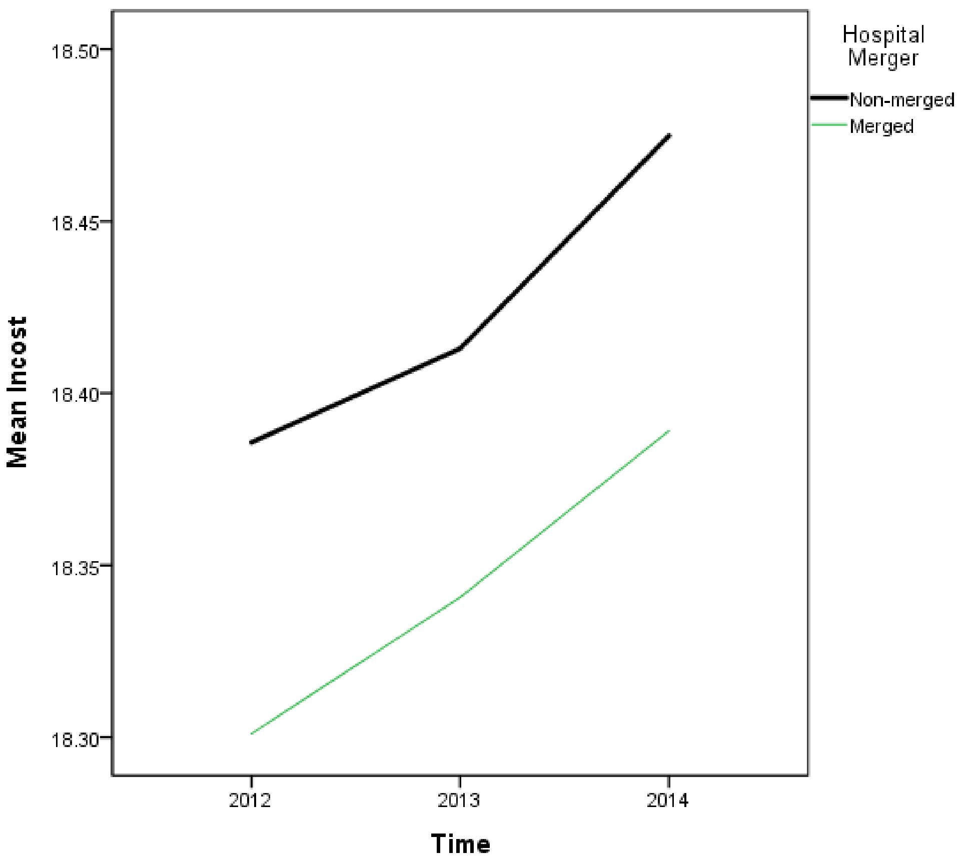


Figure 5.2 Comparisons of total operating costs from 2012 to 2014 between each group of hospitals: private vs. public

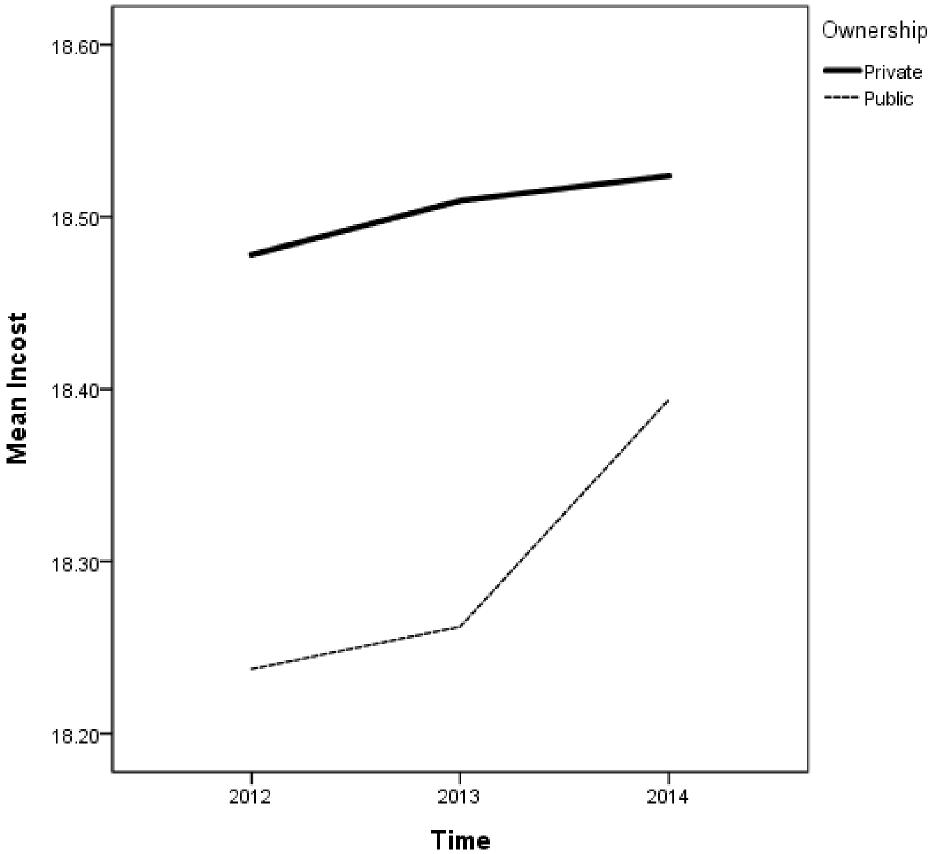
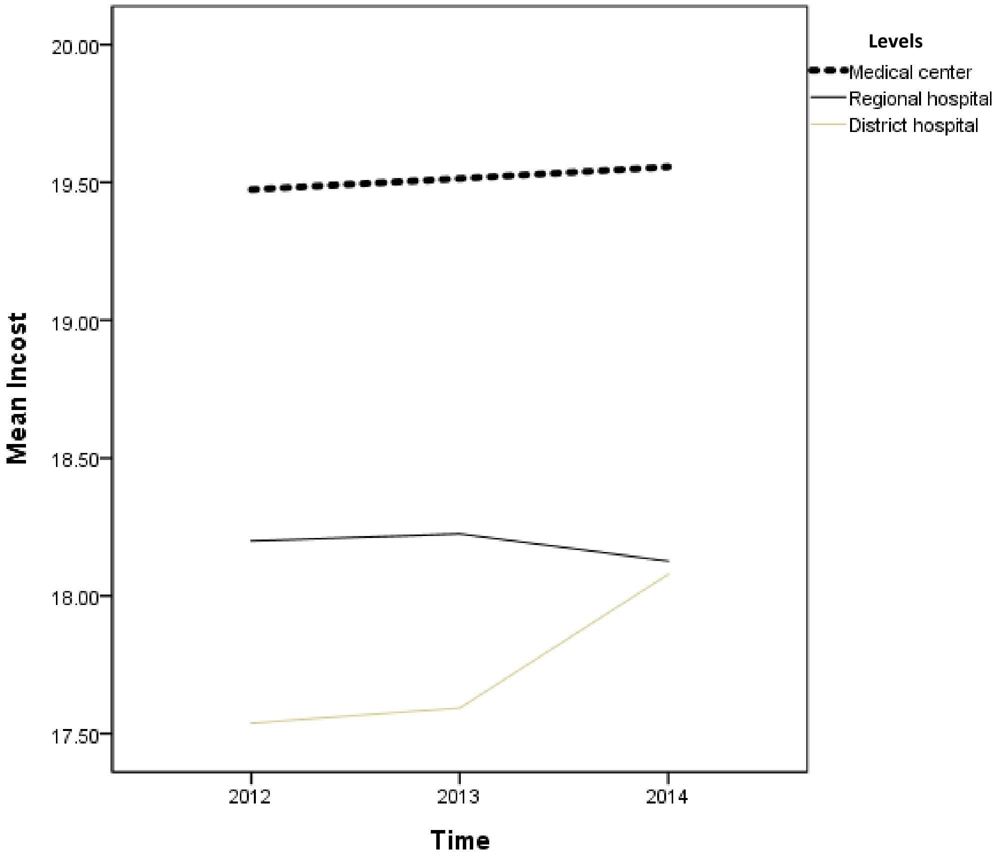
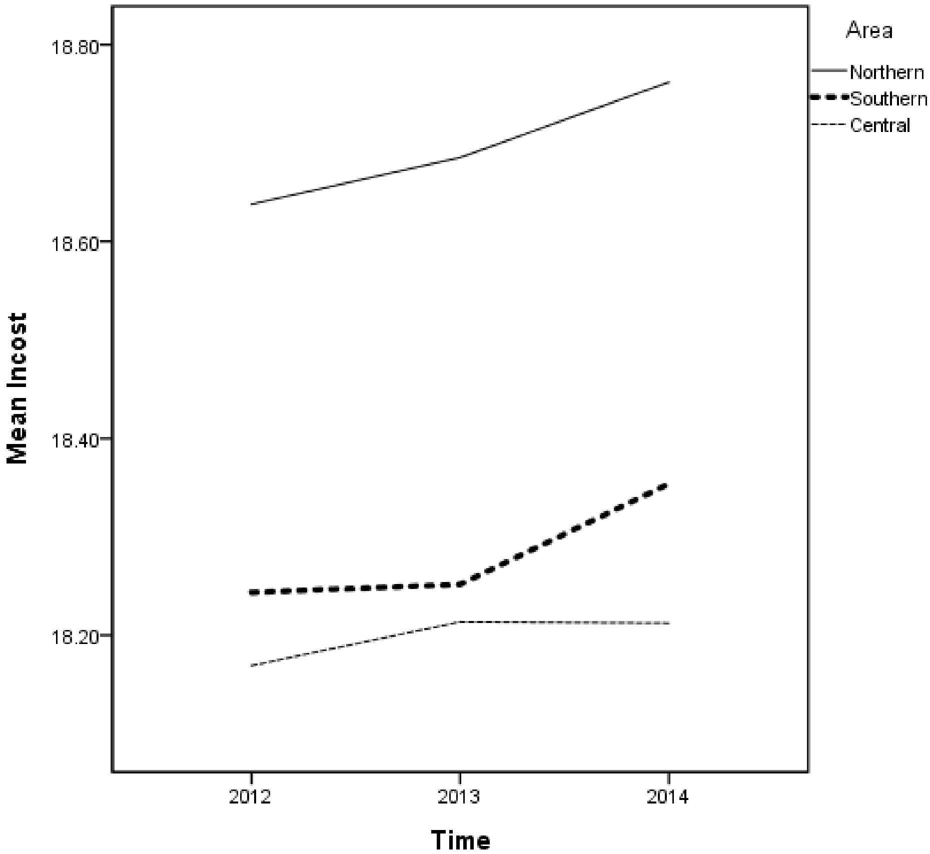


Figure 5.3 Comparisons of total operating costs from 2012 to 2014 among each group of hospitals: medical centers vs. regional vs. district hospitals



Location

Figure 5.4 Comparisons of total operating costs from 2012 to 2014 among each group of hospitals: northern Taiwan hospitals vs. southern Taiwan hospitals vs. central Taiwan hospitals.



CHAPTER 6: DISCUSSION

Overview

The main goal of this research is to add to the limited existing research in Taiwan regarding the effects of hospital factors on hospital costs and quality of care. This research contains three studies with the following objectives: (1) Integrates the results of 11 previous independent studies on the effect of hospital competition on quality of care to derive conclusions about the association; (2) Identify the factors such as hospital merger, competition, ownership, level, location, the number of acute beds are associated with quality of care; and (3) Investigate if the factors such as hospital ownership, competition, merged/non-merged, location, the number of acute beds, the occupancy rate, time are associated with hospital costs. Most of the findings in this research are consistent with those of previous research. This chapter provides a summary of the main findings of this research, its limitations, policy implications, and recommendations for future research.

Main Findings

Chapter 3 is a systematic review and meta-analysis of previous research about the effect of hospital competition on quality of care. Eleven studies are included in the analysis. All studies use 28 or 30-day AMI mortality rates as one quality measure and some studies include more quality measures. For instance, there is one study that uses

36 measures, one that applies 18 indicators, and one that employs 4 different mortality rates. In terms of competition measures, all studies mainly use HHI and/or the number of competitors in the marketplace but three studies use both and one study applies twelve different measures. Based on the qualitative review, among the eleven studies selected, four studies demonstrate that hospital competition significantly reduces AMI rates (better quality) while four studies show increased AMI rates (worse quality). The remaining three depict insignificant decreased quality. However, the results of the meta-analysis depict that the pooled effect of hospital competition is reduced quality, although the overall effect is statistically insignificant. Moreover, the results of meta-regression demonstrate that the year of publication is a crucial source of heterogeneity. Cumulative study indicates that the magnitude of the impact of hospital competition on mortality rates reduces over time. The implications from both results are that the continuous policy attention on improving quality of care as well as improvement in medical technology and practices may have helped reduce AMI mortality rates.

The results from the above study lead to the examination of other potential factors which may also influence quality of care. Thus, in Chapter 4, the association of hospital merger, ownership, hospital levels, location and quality of care are investigated. The study finds that hospital levels, ownership, and location are significantly associated with quality of care. However, hospital mergers are found to have an insignificantly mixed association with quality of care. Generally speaking, the study finds that medical centers and regional hospitals have poorer quality than district hospitals. This may be partly due to the overcrowding of patients with mild illnesses in these hospitals which affects the delivery of care provided to patients with more severe and complex conditions.

Moreover, all levels of hospitals are significantly associated with poor quality in term of Revisit. This is evidenced in the 2014 Population Healthcare Quality Indicator by MOHW, which shows ratings being poorer than those of OECD countries in the quality aspect in terms of whether doctors' are communicating with patients efficiently and sufficiently. Moreover, such short visits could also contribute to the continuously rising medical costs as patients tend to go for second or third visits (Wu et al., 2010). In fact, the average number of outpatient visits in Taiwan continues to rise since the inception of NHI and has reached to 15.12 visits in 2012 (Department of Health, 2016). Compared to other developed countries in the world, Taiwan's average number of outpatient visits has been one of the highest in the world (Chan, 2010). Indeed, in 2012, Taiwan has the highest average number of outpatient visits in the world (Mossialos and Wenzl, 2015). Thus, implementing strategies such as the practice of the gatekeeper system or changing hospital level to only medical centers and general hospitals so that large hospitals can focus more on medical research and caring for patients with more severe and complex diseases may help improve such situation (Lin, 2005). Policy attention to enhance the quality of care of public hospitals and to eliminate the overcrowding problem in large hospitals is important in improving quality of care in Taiwan.

Having examined the quality aspect, this study turns to the investigation of other aspects of hospital performance, such as costs. The study uses hospital factors such as the number of acute beds, the occupancy rate of the acute beds, the number of competitors, merged/non-merged hospital, hospital ownership, location, and time to examine the contributing factors that influence hospital operating costs. The study finds that the number of acute beds, the occupancy rate, and year are significantly and positively associated with hospital costs. These results are consistent with the study's predication. Moreover, these results are also in accordance with the present situation in Taiwan where the delivery of medical services is concentrated in large hospitals and the healthcare expenditures are continuing to rise in Taiwan (Hung and Chang, 2008; Lin, 2005). In contrast, the number of competitors, hospital ownership, merged/non-merged, and location are found to be insignificantly associated with hospital costs. However, such results may be due to the small sample size of this study and thus further investigation based on a larger sample of hospitals and longer period of time can help substantiate the findings.

In view of the growing aging population and healthcare expenditures, it is crucial for policy makers to understand the factors influencing the costs and to formulate strategies that can contain costs while sustaining good quality of care. Furthermore, while it is useful to have quality benchmarks, it is also crucial to ensure that hospitals have incentives to maintain good quality of care as well as containing their costs. Linking quality performance with reimbursements may be an effective practice (Chang, 2011; Rosenthal et al., 2005; Ward, 2016). The following table summarizes the findings from Chapter 4 and 5.

Hospitals characteristics	Higher rates (lower quality)	Lower rates (higher quality)	Mixed quality	Higher costs	Lower costs
Merged			√		√
Non-merged			√	√	
Private		√		√	
Public	√				√
Medical CTR	√			√	
Regional	√			√	
District		√			√
Northern	√			√	
Central			√	√	
Southern		√			√

Limitations

There are several limitations that need to be addressed when interpreting the findings of the research. First, due to the limited access to hospital level data such as averaged length of stay, case mixed index, the number of discharges, and patient level data, these potential influencers are not included and examined in this research. The scope of the findings from this study is thus limited. The study attempted to address this limitation by including variables such as occupancy rate, hospital levels, and the number of competitors. The purpose was to find out whether these variables do have an impact on hospital quality or costs. Second, the study is limited by the time period of data due to the unavailability of longer-term data. Third, the research may also be limited by its small sample size, and thus the test of the significance of the effects of the factors on quality or hospital costs may be restricted. Therefore, when data is made available, the author intends to include a larger hospital sample size, patient level data, and hospital level data with a longer period of time to conduct further analysis. This will help substantiate the findings of this study, and provide a better understanding on the potential factors that may influence hospital quality of care or costs. This will strengthen the representation of the findings and provide greater value to their pertinence. Moreover, the non-random selection of the case can lead to selection bias. Inclusion of all hospitals or randomly select the hospitals can help overcome this issue for future study. Furthermore, in Chapter 3, to avoid publication bias, unpublished studies were included. As there seems to be limited current and detailed research on the pooled effects of hospital competition associated with quality of care, the effects of hospital factors associated with quality of care, and the effects of hospital factors associated with hospital operating costs, this study will serve as a foundation for further research on these topics.

Policy Implications

There are significant implications on quality of care and hospital costs from the findings of this research. For instance, one of the findings from this study indicates a significant association between all hospitals and quality in terms of Revisit. Under the existing reimbursement policy, reimbursements to physicians will be reduced in accordance with the number of outpatients exceeding the certain thresholds set by the NHI (Lee, 2001). However, physicians are not likely to restrict the number of outpatients even if their reimbursements are reduced based on the scaling number of patients they see (Chu, 2001). As such, each patient may receive less than 5 minutes of consultation on a visit, and thus patients are likely to go for a second or third visit (Wu et al., 2010). While patient volume increases, medical costs also rise as a result (Ibid). However, hospital revenues increase in accordance with patient volume (Ward, 2016). Thus it seems reasonable for BNHI to implement such a policy to reimburse providers on a scaling basis. Taiwan has a ratio of 6 to 4, which indicates that the BNHI spends about 69% of total health expenditures on outpatient services and 31% on inpatient services in comparison to the ratio of health expenditures on outpatient and inpatient services, for OECD countries, which is 4 to 6 (Chu, 2001). This may suggest that the number of outpatient services is too high and the focus on the treatment of severe diseases and inpatient services has been overlooked in Taiwan (Ibid). Although it may seem reasonable to shift the focus of hospital services from outpatient to inpatient and to control the high costs of NHI, this practice may inevitably affect the quality of care of hospitals.

In Taiwan, hospitals must be accredited by the Taiwan Joint Commission on Hospital Accreditation (TJCHA) which classifies hospitals into three levels based on the accreditation results: medical centers, regional and district hospitals (Chang et al., 2011). Hospitals are reimbursed in accordance with their levels (Lee, 2014). Hospitals of the same level receive the same reimbursement schedule; however, for the same type of care provided (i.e. based on the disease codes assigned by the BNHI), medical centers receive the highest reimbursement, followed by regional and district hospitals (Chang et al., 2011). Moreover, as hospitals are reimbursed a fixed amount, then they (especially private hospitals) would seek any possible way to increase their revenues (Lin et al., 2003). Furthermore, as an unintended consequence of the accreditation, resources are allocated mainly to large-scale and urban hospitals (Lee, 2014). Indeed, the process of accreditation has been criticized for being burdensome to healthcare providers (Liu, 2015). Also, the information provided by hospitals has been identified as being fraudulent as some of the requirements and standards are unachievable, therefore some hospitals forge the data (Chen, 2016). As such, government organizations shall develop and unify quality measures or metrics that are manageable for healthcare providers, and can provide reliable results that can link healthcare reimbursements with quality of care. This would help contain hospital costs while ensuring good quality of care. For instance, a total patient harm rate that contains various harm measures such as adverse drug event, hospital acquired infection rate, fall rate, and pressure ulcers can reflect the levels of efficiency of a hospital (Ward, 2016). The hospitals can then be reimbursed based on their levels of efficiency.

It is a challenge to maintain good quality of care while containing costs (Chang, 2011). In view of the growing aging population and increasing medical needs, healthcare expenditures are expected to continue to grow (Lin, 2015; Hung and Chung, 2008). While cost containment is important, sustaining good quality of care is also crucial. However, the current practice seems to emphasize cost containment more than improving quality of care (Chang, 2011). Policy makers shall identify and unify quality measures that can link performance with reimbursements (Chang, 2011; Rosenthal et al., 2005; Ward, 2016). As such, costs can be contained without creating deleterious quality of care. In addition, this research finds that competition does not show statistical significant impact on hospital costs and quality. However, this may be due the small sample size of the study. As healthy competition can induce continuous improvements in technology, medical practices, and methods, hospital costs can be reduced and quality can be enhanced consequently (Porter and Teisberg, 2004). Policy makers ought to seek ways to encourage healthy competition among healthcare providers by making hospital data transparent so that they can compare and learn from the best performers.

Future Research

Due to the current limited research on the associations of hospital competition, hospital factors with quality of care and hospital costs in Taiwan, further research on such associations is suggested. For meta-analysis on quality of care, the inclusion of more studies when they are available will help substantiate the findings from this study. For future research on the association of potential factors that may influence quality of care, employing a larger sample of hospitals, a longer period of time, and other quality measures will be helpful in assessing if the results from this study are consistent in other settings. Similarly, for future research on hospital costs, the inclusion of a larger sample of hospitals, a longer period of time, and other factors such as average length of stay, case-mix index, hospital discharges, and patient level data could add greater validation to the study’s robustness.

Conclusion

In view of the growing healthcare expenditures and the aging population in Taiwan, it is crucial to discover the factors that impact hospital costs and quality of care in order to ensure the continuity of the National Health Insurance program and to sustain good quality of care. The study identifies the potential factors that may contribute to the quality of care and hospital costs, although other factors may also be of influence quality of care and hospital costs. Nevertheless, this study provides a foundation for further investigation and analyses on these associations. The factors identified are not causes of the rising costs and deteriorating quality of care, yet they lead to the fundamental problems pertaining to the costs and quality of care in Taiwan. They are detrimental through this association. However, before policies can be implanted effectively and successfully, certain aspects must be considered. The most important aspect would be the organizational culture of a hospital. Only a hospital with a culture that advocates increasing efficiencies and eliminating medical waste and errors can ensure policies aimed at reducing medical waste and improving quality of care can be implemented effectively. However, reinforcing such culture may be the most difficult part to achieve as it is a long-term process. Regardless, it is only through the building of such culture that quality can be improved and costs can be contained ultimately. When hospitals all reinforce such culture, policy attention focusing on reducing medical waste and ensuring good health outcomes can be effectively implemented. Furthermore, policy makers shall identify the quality measures that matter to patients, enforce all hospitals to use them, ensure the transparency of such quality data, and encourage all hospitals to compare and learn from each other. Most importantly, they need to link performance with reimbursements to ensure costs are contained and good quality of care is maintained.

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CURRICULUM VITA

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WORK EXPERIENCE

15 – Today

Hua Nan Bank. (listed in Taiwan Stock Exchange, stock code: 5838)

Board director

- Act on behalf of the shareholders to govern the organization and to protect the assets of the Bank
- Appoint, supervise, and evaluate the executive officers of the Bank
- Formulate strategies, establish bank policies, and supervise business activities
- Approve financial statements

14 – Today

Hua Nan Financial Holdings Company Ltd. (listed in Taiwan Stock Exchange, stock code: 2880)

Board director

- Govern the holding company and its six subsidiaries
- Appoint, supervise, and evaluate the executive officers of the holding company and its subsidiaries
- Establish policies and review strategies, financial objectives, and operating plans of the Group
- Approve financial statements

05 – 14 **Hua Nan Financial Holdings Company Ltd. (listed in Taiwan Stock Exchange, stock code: 2880)**

Board Supervisor

- Approve financial statements
- Verify risk-management and internal control policies that are being effectively implemented
- Work with board directors to decide on issues of policy and procedures that affect the company
- Incorporate the concerns of those who are not members of the board to ensure their concerns are considered during board meetings

06 – 15 **W.W.C. Foundation**

Chief Operations Officer

- Evaluate the impact of funding decisions and investment strategies
- Work with the board to make decisions on funding choices
- Work with the board to develop financial strategies that are effective and ensure that such strategies are implemented well

03 – 05 **Hong Kong and Shanghai Banking Corp. Ltd., Taipei**

Vice President, Treasury Department

- Provide advice on foreign exchange hedging, interest rate hedging and investment strategies to large local corporates and multinational companies
- Promote and marketing products such as structured foreign exchange and interest rate products
- Explore business opportunities

00-03 **Deutsche Bank, Taipei Branch**

Assistant Vice President, Corporate Banking

- Maintain banking relationships with large multinational companies to develop business

opportunities
- Provide analysis on corporate clients' financial reports and industry outlooks
- Review credit lines and provide advice on credit approval
- Develop business opportunities with existing and potential clients

96-98 **Bank of Nova Scotia, Taipei Branch**

Account Officer, Financial Institutions

- Provide analysis on local banks' financial reports and outlooks
- Review credit lines and providing advice on credit approval
- Develop business opportunities with existing and potential clients

92-94 **Bank of Nova Scotia, Vancouver Chinatown Branch**

Senior Accounting Officer, Operations

- Prepare and auditing accounting reports such as investment reports, credit outstanding reports
- Prevent abuses such as money laundering by performing credit checks
- Ensure accuracy of tellers' daily paying transactions and check tellers' work
- Promote bank products and services

EDUCATION AND QUALIFICATIONS

12-Today **Johns Hopkins University**

Bloomberg School of Public Health

Part-Time Pacific Rim Dr. PH Program in Health Care Management and Leadership

08-08	Securities & Futures Institute Common problems in Listed Companies' Financial Reports and their Legal responsibilities
07-07	Securities & Futures Institute Taxation Certificate
06-06	Securities & Futures Institute Impact on Financial Statements as a result of changes in accounting rules Certificate
05-05	Securities & Futures Institute Board Directors and Supervisors' responsibilities Certificate
98-99	**University of Birmingham (Birmingham, U.K.)** **M.B.A.** (International Banking and Finance)
97-97	Professional Training (Taipei, Taiwan) Certificate of Dale Carnegie Course- Interpersonal& Communication Skills
94-95	Tokyo YMCA (Tokyo, Japan) Japanese Language and Cultural Exchange Program
90-94	The University of British Columbia (Vancouver, B.C.) Bachelor of Arts

93-94	The Institute of Canadian Bankers (Vancouver B.C.) Securities Program- Canadian Mutual Funds
88-90	Sentinel Secondary School (Vancouver, B.C.) Canadian High School Diploma

VOLUNTEER WORK

09-2014	Assisting in research studies for Center for Geriatrics and Gerontology, Taipei Veterans General Hospital

JOURNAL PUBLICATION

1. **Shen V**, Liu LK, Chen LK. Taking into account of frailty in treating older patients with cardiometabolic disease. J Nutr Health Aging (in press) [Impact factor: 2.484, Rank: 16/45 in Geriatrics and Gerontology of SCI]

2. Tao P, Lin MH, Peng LN, Lee WC, Lin FY, Lee CH, Chien CW, **Shen V**, Chen LK. Reducing burden of morbidity and medical utilization of older patients by outpatient geriatric services: implications to primary health care settings. Gerontol Geriatr Int (in press) [Impact factor: 1.782, Rank: 10/30 in Gerontology of SSCI]

3. Huang WF, Chang LC, Kao YH, Wen YW, Hsiao FY, **Shen V**, Tsai YW, Chen LK. Prolonged risk of subtrochanteric and proximal femoral shaft fracture after discontinuing alendronate treatment: a nationwide nested case-control study in Taiwan. J Clin Endocrinol Metab (in submission) [Impact factor: 6.495, Rank: 13/116 in Endocrinology and Metabolism of SCI]

ADDITIONAL INFORMATION

Languages	English, Mandarin, Cantonese, Taiwanese and Japanese

Reference

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